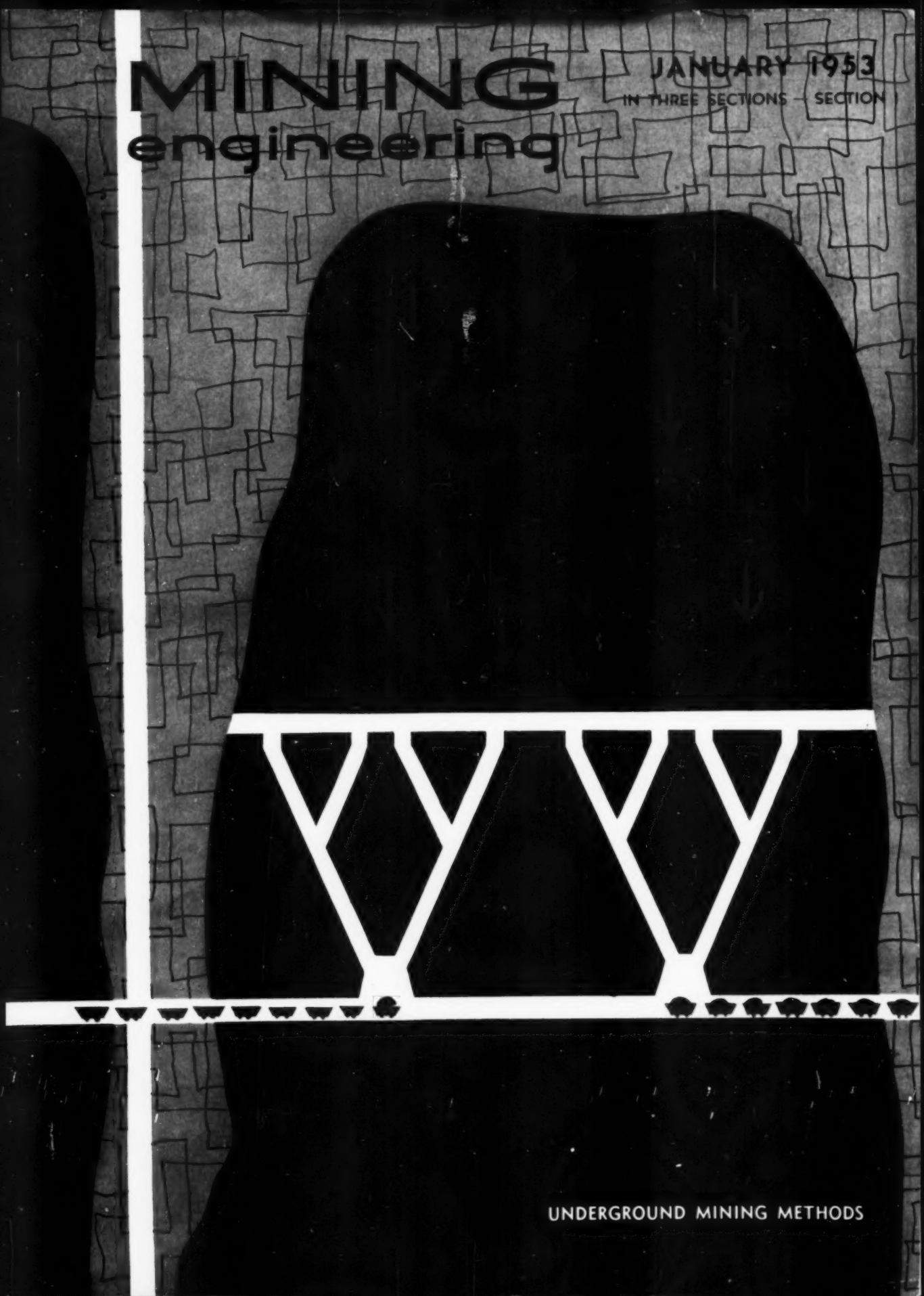
MINING engineering

JANUARY 1953
IN THREE SECTIONS — SECTION I



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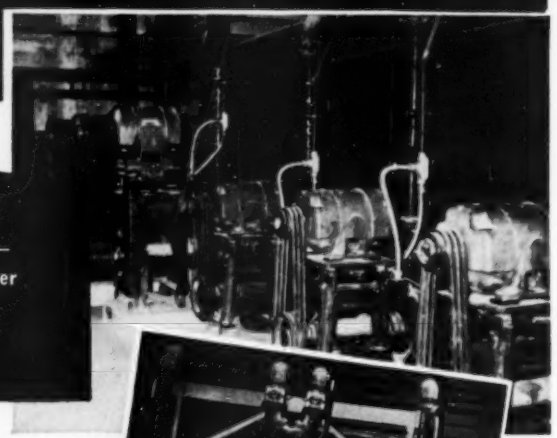
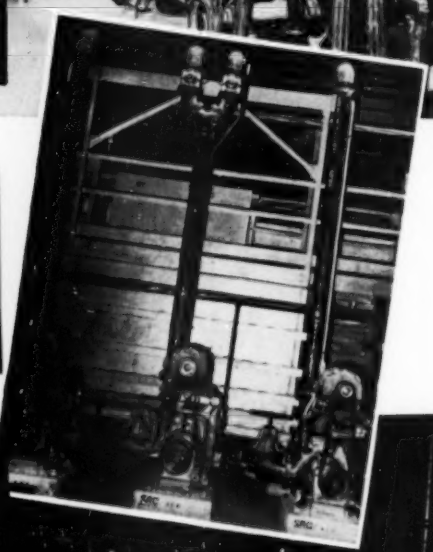
In the World's Greatest Open Pit Copper Mine and Sulphide Plant at Chuquicamata, Chile

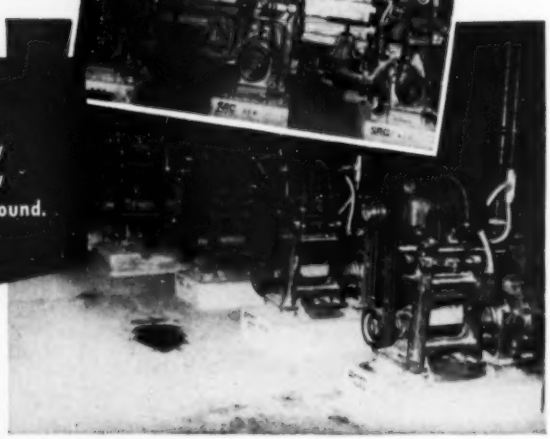
Wilfley Sand Pumps **are an integral part of the huge operation carried on in the fabulous new $100,000,000 plant at Chuquicamata, Chile. Day and night dependable Wilfley's deliver continuous, trouble-free performance . . . playing a major role in the dramatic success of this great mining enterprise.**



Primary Rougher Overflow Pumps—Secondary Rougher Overflow Pumps in background.



Secondary Cleaner Tails Pumps—Secondary Cleaner Overflow Pumps in background.



Final Concentrate Pump—Secondary Rougher Overflow Pumps in background.

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The new Model "K" Wilfley Sand Pump answers the 3 important economic considerations in the handling of solids: **1.** High Operating Efficiency—the Model "K" features important mechanical improvements which give you substantial dollar savings in power and production costs. **2.** Low Maintenance Cost—Wilfley's precision engineering assures dependable operation with a minimum replacement of parts. **3.** Minimum Installation Expense—the Model "K" is specially designed for simple installation, saving plant operator's time, trouble and added expense.

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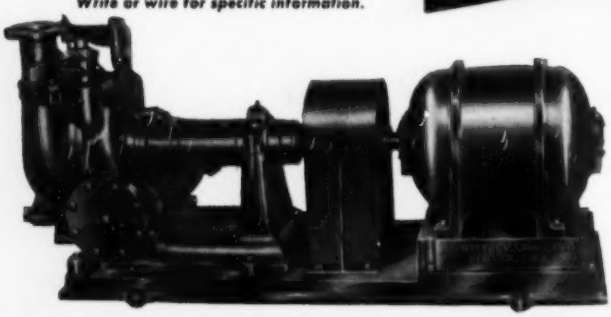

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MINING engineering

VOL. 5 NO. 1 JANUARY, 1953

IN THREE SECTIONS—SECTION 1

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COVER

Cover Artist Herb McClure's symbolic cover announces the 26-page transaction, "Underground Mining Methods at International Nickel Company," which starts on page 57.

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Section 2 is the Directory and Year Book of AIME which is mailed only to members.

—Personnel Service—

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

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Mining Engineer, 29, single, B.S. in geology, B.S. and M.S. in mining engineering. Four years heavy construction experience with Army Engineers. Two years mechanical project engineer with major basic chemical company doing construction work, precise surveying and pipeline design. Prefer eastern U. S. Available 30 days notice. M-1.

Mill Superintendent, Assistant Superintendent, General Foreman or Field Engineer, 49, married. Twenty-five years experience mill operations and supervision of construction and plant maintenance for mill, smelter and acid plants. Speak Spanish. Available immediately. Prefer southwest U.S.A. M-2-5211-E-1-San Francisco.

Mining Engineer and Geologist, E.M., registered, M.S. in geology, 37, married. Broad engineering experience exploration, development and production of base, precious and rare metals; including examination and appraisal, exploration planning, organization, supervision and administration; report writing, reviewing and analysis. Pre-professional hard-rock mining experience. Desire position progressive concern. M-3.

Mining Engineer and Geologist, 39, experienced management and research; open-pit, placer and underground mining; construction, light weight aggregates, prestressed concrete and explosives; excellent Spanish; seeks position, contract or salary, in production or exploration; U. S. or foreign. M-6.

Safety Engineer, 48, married. Twenty-five years experience underground mining operations, flat and pitch, ventilation, mine development, mine fire control and recovery, dust control. Twelve years safety department direction. Familiar with laboratory technique for analyses of gases and dust counting. Registered professional engineer. M-7.

Mining Engineer, technical graduate. Experienced examination, exploration, development and operation underground and open-pit mining. Heavy construction and stripping. Technical reports. Employed, married, good health, 49. M-8.

Mine Superintendent or Manager, 42, married. Fifteen years wide mining experience U. S. and Mexico. Now employed western metal mine. Will consider offer in U. S. or Mexico with stability and future. M-5.

POSITIONS OPEN

Mining Engineer, registered, with several years experience in coal mining. Location, West Virginia. Y7935.

Sales Engineer, 28 to 35, mining or mechanical degree, with minimum of five years experience or equivalent in selling in the New York area. Company manufactures mining equipment. Extensive traveling. Must have car. Salary, $5200 a year and expenses charged against a commission basis. Territory, New York and adjacent area. Y7916.

Mining Engineers, 2, young, with college background and one or two years experience or at least summer vacation experience working in mines. Bulk of mining is open-pit work with shovels, draglines, bulldozers, trucks, etc. Milling operations include both wet and dry operations. Machinery used includes coarse and fine crushing machinery, jigs, ball mills and Raymond mills; vibrating screens, classifiers, dewaters and thickeners, centrifuges and flotation machines, etc. Starting salary, $3900 a year. Location, one for Arkansas and the other for Missouri. Y7888.

Vice President, 35 to 40, mining engineer, with experience in management and business, to take complete charge of production, engineering, quality control, etc. for a lime and stone company. Salary, $10,000 to $12,000 a year. Location, South. Y7871.

Sr. Research Metallurgist, 35 to 45, with 5 to 10 years broad experience in concentration and flotation milling. Copper leaching experience desirable. Salary open. (b) Chief Chemist, 35 to 40, with knowledge of up-to-date techniques gained by experience in modern laboratory handling volume of analyses and assays of ores, concentrates and mill products. Salary open. Three year contract. American company. Mediterranean area. Transportation expenses paid for man and family but applicant must report single status for first six months. Apply by letter. S699.

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Box A-1 MINING ENGINEERING

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Henry Krumb Scholarships
William Campbell Fellowships

Applications are invited for the Krumb Scholarships and Campbell Fellowships for the academic year 1953-1954. These are available to candidates for degrees in the fields of Mining, Mineral, and Metallurgical Engineering.
The Krumb Scholarships, with yearly stipends of $1000 and transportation to New York City, are in support of studies toward the B.S., M.S., or professional engineering degrees. Preference is given to students in mining engineering in the ratio of three in this field to two in metallurgical and mineral engineering.
The Campbell Fellowships, established to encourage research in the general field of metals, are available to candidates for graduate and professional degrees including the Ph.D. Five grants are usually awarded each year, with stipends of $1800 for single students and $2100 for married students.
Application blanks and further information may be obtained on request to the Office of University Admissions, Columbia University, New York 27, N.Y. Complete applications should be returned before February 20, 1953.

POSITIONS AVAILABLE

The Bureau of Mines is recruiting mining engineers, metallurgists, and fuel technologists, to serve abroad on mining projects conducted under the Point Four and other foreign programs. Salaries range from $5,000 to $9,000 per annum, depending on the qualifications of the applicant, the responsibilities of the assignment, and the area in which the work is done. There are also rental, and in some areas other allowances to compensate for unusual conditions encountered abroad. Some short-term assignments are available from time to time but most of the positions carry a minimum two-year tenure of office. Travel expenses for the employee are paid under all circumstances and for the longer-term assignments travelling expenses for family and transportation of a limited quantity of household goods are provided. United States citizenship and security clearance are mandatory for applicants, and United States citizenship for wives who accompany their husbands abroad also is required. Applicants must be physically capable of performing rugged work in the field. Additional information can be obtained upon application to the office of the Regional Director, Region IX (Foreign Minerals), Bureau of Mines, Washington 25, D. C.

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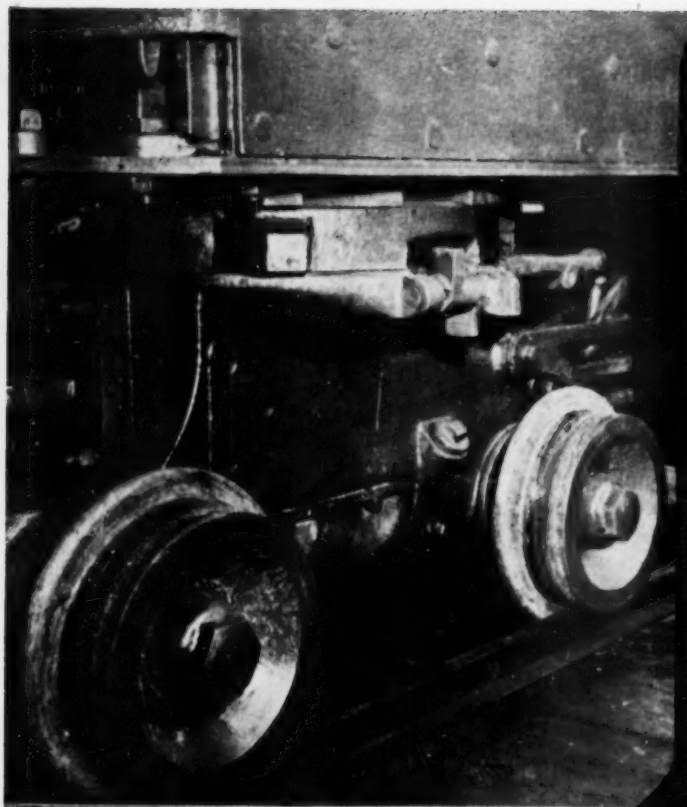

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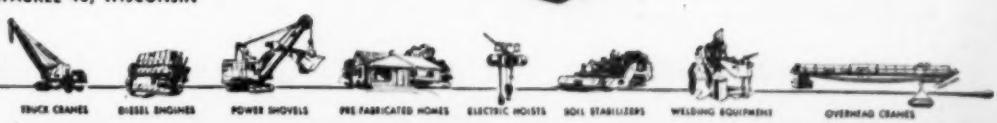
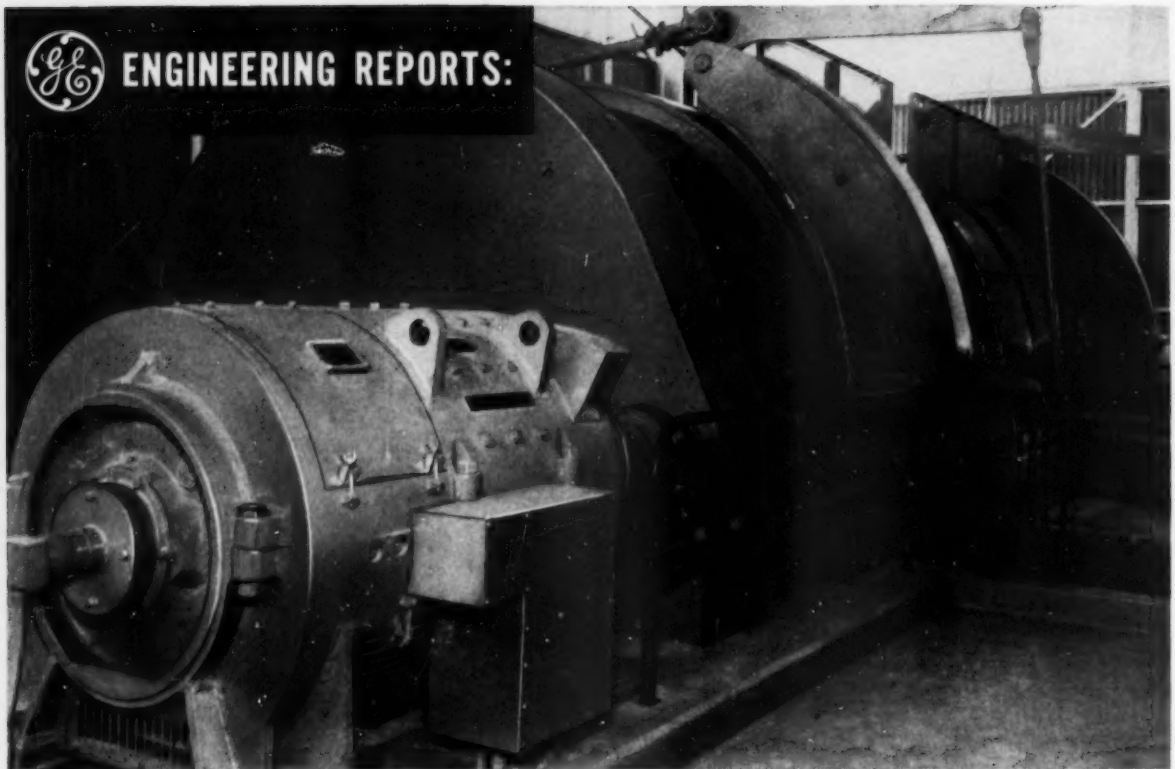
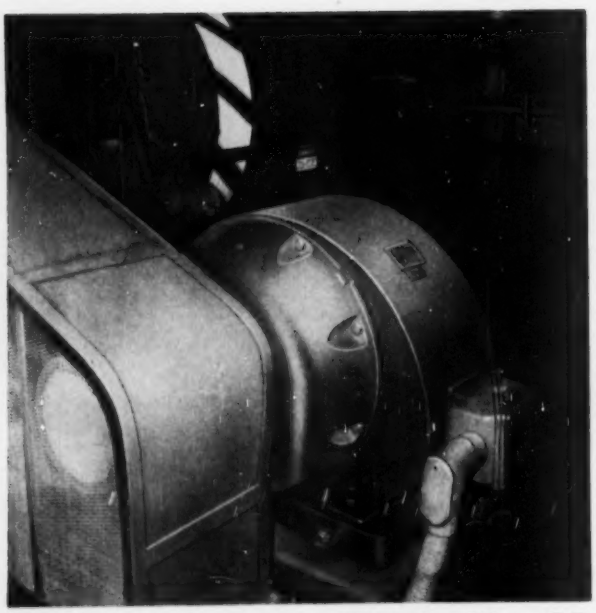


TRUCK CRANES · DIESEL ENGINES · POWER SHOVELS · PRE-FABRICATED HOMES · ELECTRIC HOISTS · SOIL STABILIZERS · WELDING EQUIPMENT · OVERHEAD CRANES



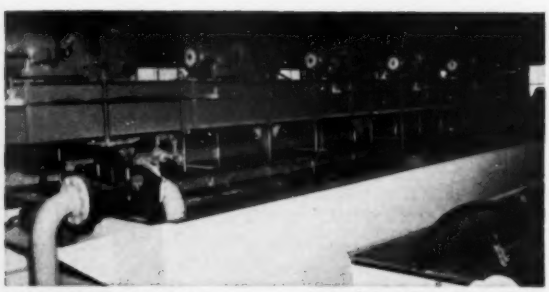
AUTOMATIC MINE HOIST at Duval—amplidyne-controlled and driven by a 600-hp G-E MDP motor—hoists 6 tons of ore up 1628 feet in 103 seconds. Maximum speed is 1100 fpm. Loading, acceleration, deceleration and dumping are all automatic.

Co-ordinated electric equipment



ROD MILL inside refinery is driven at 19 rpm by a 720-rpm G-E Tri-Clad* synchronous motor rated 250 hp, 440 volts.

*Registered Trade-mark of General Electric Company.

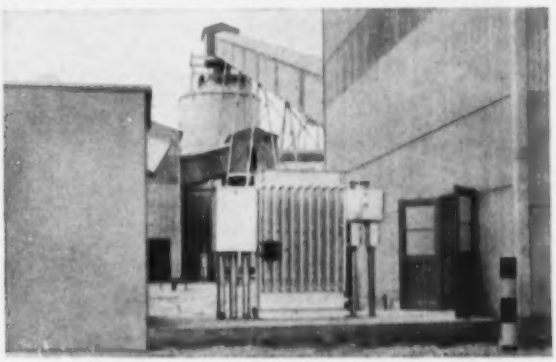


FLOTATION CELLS shown are agitated by five 5-hp G-E motors, totally enclosed, fan-cooled against corrosive vapors.

CENTRIFUGES, another step in the process, are driven by these 150-hp G-E Tri-Clad wound-rotor motors.

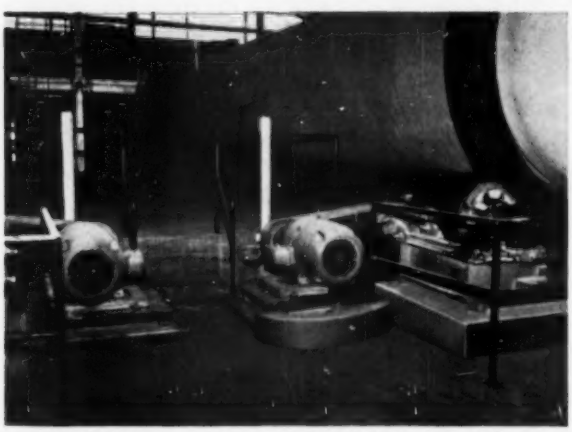
CONTROL OF MAIN ORE HOIST can also be manual by means of master control located in this hoist console.

POWER purchased by Duval is stepped down from 67,000 to 4160 volts at this G-E 5000-kva master unit substation.



DEPENDABLE G-E TRANSFORMERS step down 4160 volts to 480/277 volts grounded-neutral at 6 utilization areas.

keeps Duval potash output high



DRYING KILNS, where the refined potash is prepared for shipment, are driven by 40-hp G-E totally enclosed motors.

System engineered for efficient operation of automatic hoist and refinery drives

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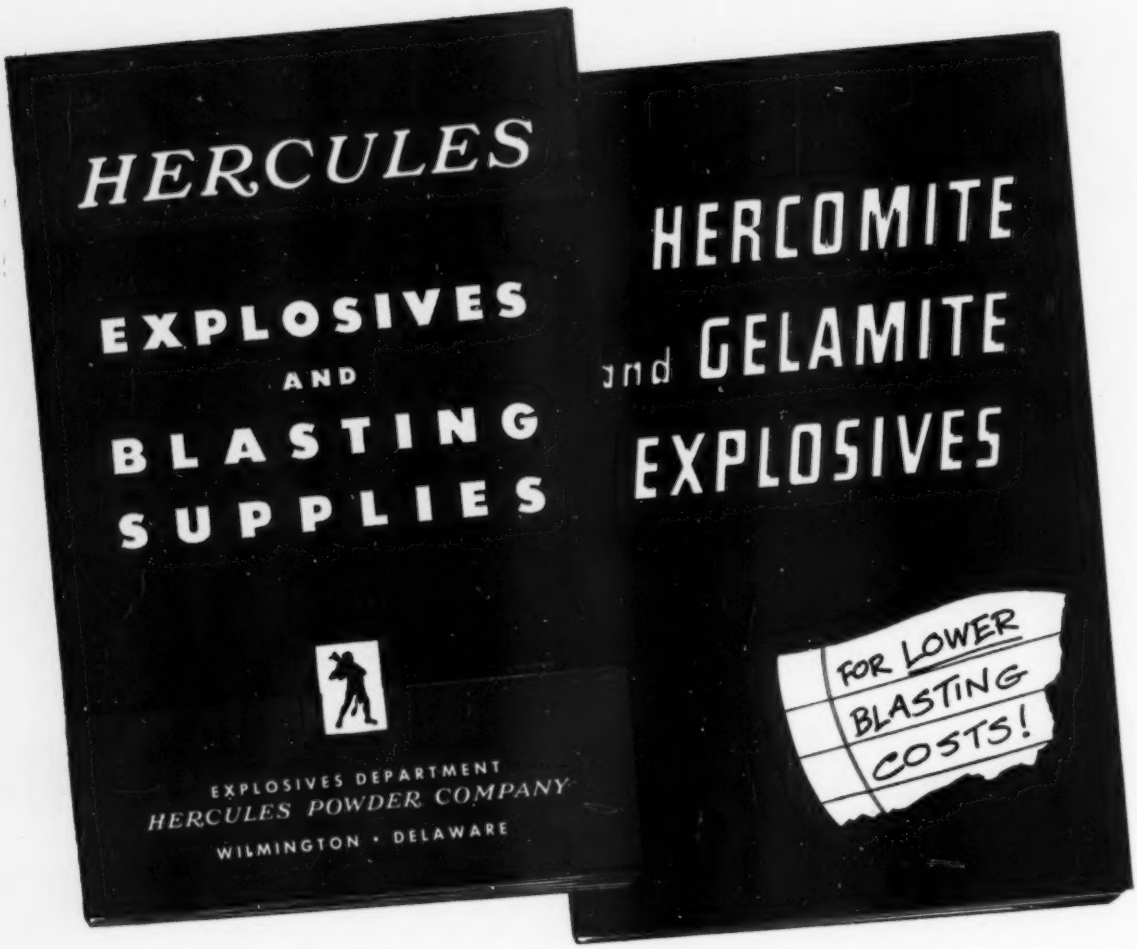

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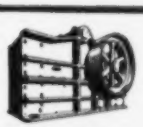
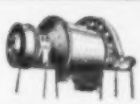

Jaw Crushers

Gyratory Crushers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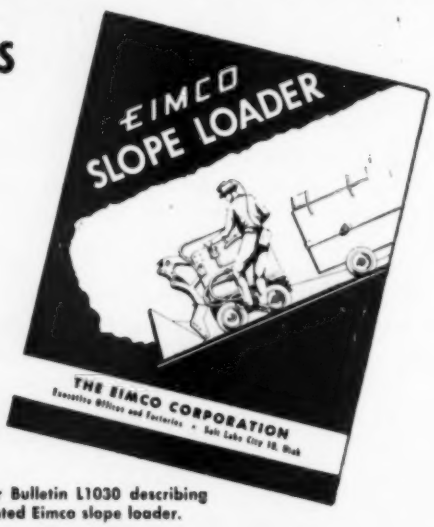

Write for Bulletin L1030 describing patented Eimco slope loader.

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You Can't Beat an Eimco

Meet The Authors

Ray E. Gilbert *(Geophysical Explorations,* P. 53) is now a geologist with Day Mines, Inc., after working for the Jardine Mining Co., Metals Reserve Co., Minas Geraes (Brazil), and New Park Mining Co. He graduated from Montana School of Mines with a Bachelor of Science in Geology in 1939. His hobbies include photography and skiing.

H. J. Mutz *(Underground Mining Methods at International Nickel Co.* P. 57) has been Inco's superintendent of mines since 1935. He came to Inco in 1929 on loan as consulting engineer on installation of the fill system of mining at Frood mine. He was asked to take over as mine superintendent. He has also been assistant superintendent of mines of the United Verde Copper Co., Jerome, Ariz. A graduate of Missouri School of Mines and Columbia University, he is a member of AIME. Golf, bridge, and hunting provide leisure time interests.

A. F. Brock *(Underground Mining Methods at International Nickel Co.,* P. 57) is a graduate of the Faculty of Applied Science of the University of Toronto. He was employed by the Canadian Copper Co., in 1911, immediately after graduation. He has worked for that company, and its successor, Inco, ever since as head surveyor, mine engineer, assistant superintendent of Frood mine, superintendent of the Frood open pit, and operating engineer of mines. He lives at Murray Mine, Ont.

W. J. Taylor *(Underground Mining Methods at International Nickel Co.,* P. 57) started his mining career with Inco in 1939, after graduation from the Faculty of Applied Science at the University of Toronto, and more recently has been mines research engineer with the Research and Planning Mine Developments department. From 1941 to 1945 he headed the Contract and Efficiency Department at the Levack and Frood mines. His spare time interests include fishing, hunting, and curling.

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Alvin Kaufman (*Future of the Anthracite Industry*, P. 42) is a man of varied interests. He is a research associate with the Natural Resources Section of the Pennsylvania State Planning Board, but finds time to act as advisor to the Boys Athletic Club in Harrisburg, Pa., collect U.S. commemorative stamps, paint in watercolors, and is an ardent amateur photographer. A graduate of Pennsylvania State College with a Bachelor of Science in Mineral Economics, Kaufman was secretary-treasurer of Fairmont House, and the Mineral Economics Society.

John M. Kane (*Principles of Present Day Dust Collectors and Their Application to Mining and Metallurgical Industries*, P. 85) is manager of the dust control div., of American Air Filter Co., Inc. He earned a Bachelor of Science in mechanical engineering in 1933, and has been employed by American Air Filter since that time. He has been supervising engineer of the dust control div., and also its chief engineer. While at school he was a member of Tau Beta Pi, ODK, and Alpha Sigma Phi. Editor of the year book, Kane also served as assistant editor of the college paper.

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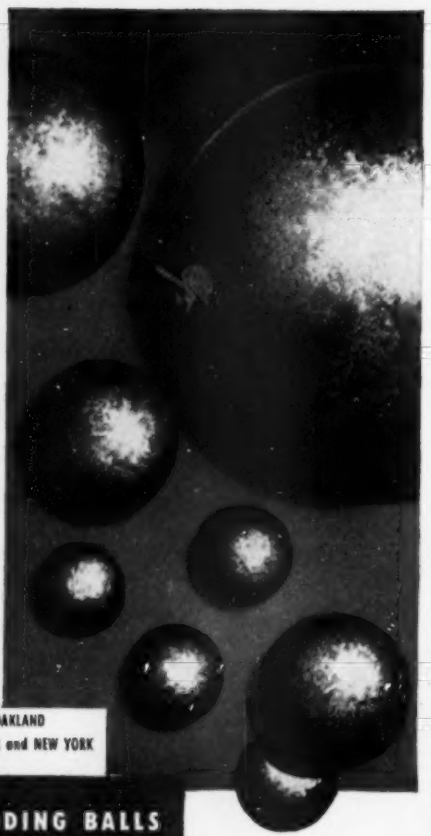


You'll find CF&I Grinding Balls where the going is toughest. They're forged from special analysis steel to give high impact and abrasion resistance ...wear evenly and stay spherical.

If you have any grinding problem, call upon CF&I metallurgists and engineers for assistance...they're always available to help you obtain the most from your grinding media.

CF&I PRODUCTS FOR THE MINING INDUSTRY

Cal-Wic Wire Cloth Screens • Grinding Balls • Wickwire Rope • Mine Rails and Accessories • Grinding Rods • Rock Bolts

THE CALIFORNIA WIRE CLOTH CORPORATION • OAKLAND
THE COLORADO FUEL AND IRON CORPORATION • DENVER and NEW YORK

CF&I FORGED STEEL GRINDING BALLS

1129

Books for Engineers

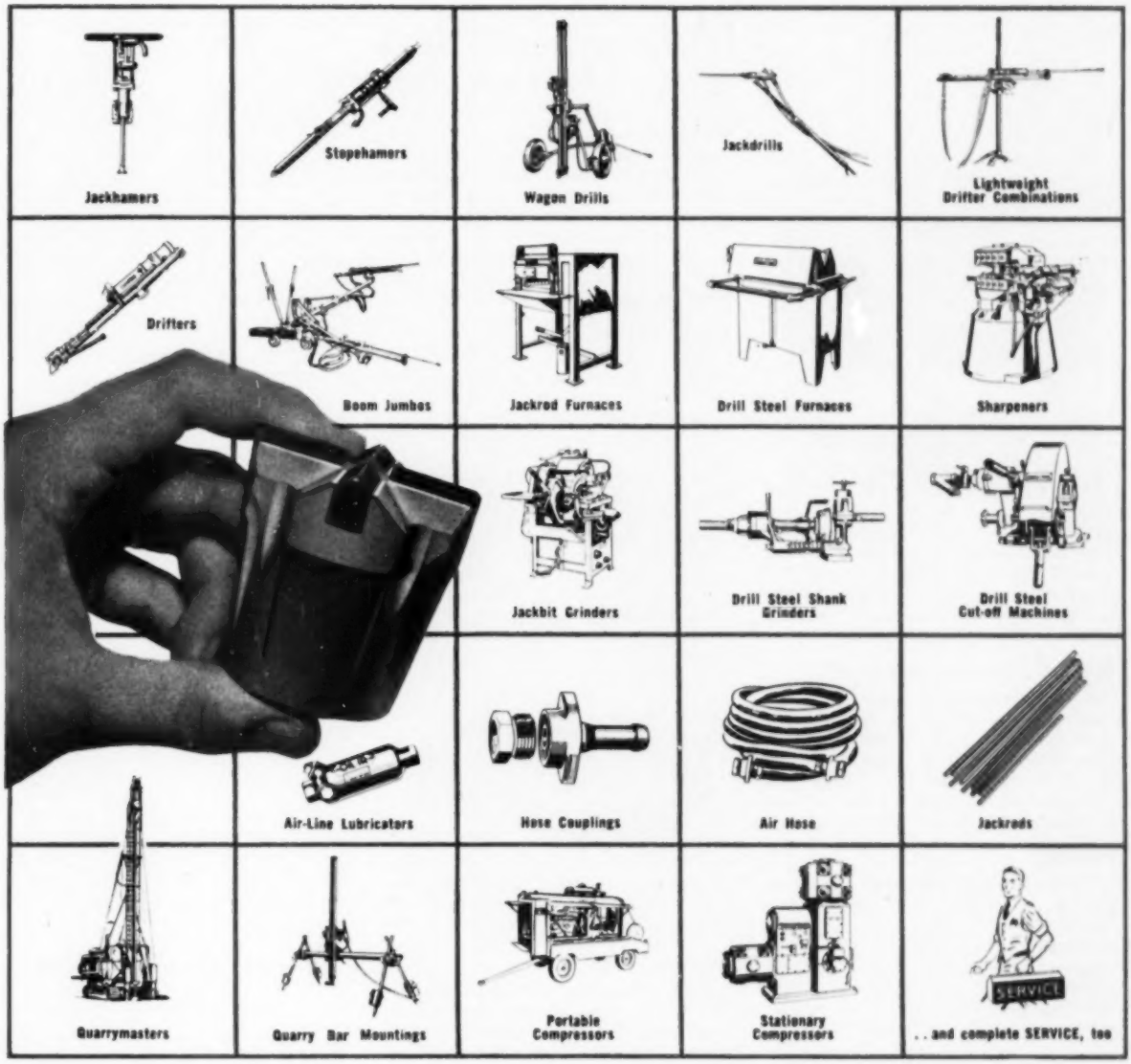
ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

Problems of Clay and Laterite Genesis. *American Institute of Mining and Metallurgical Engineers.* $4.20 to members, $6.00 to nonmembers, 252 pp., 1952.—The book is a symposium for practical and research purposes and is worthy of the attention of all geologists. Many basic problems are discussed in terms of occurrence, identification, and genesis of clays and the hydroxide minerals of aluminum and iron. The scope of the volume ranges from prospecting techniques through interpretation of X-ray and other experimental data.

Coal Mine Modernization 1952. *The American Mining Congress.* $3.00, 371 pp., 1952.—The papers, discussions, and committee reports heard at the 29th annual coal convention are brought together in this one volume. Topics are discussed under these section headings; roof support, continuous mining, longface mining, rail haulage, belt haulage, maintenance, safety, coal preparation, and strip mining.

Tulsa Geological Society Digest, Volume 20. *Tulsa Geological Society.* $2.00, 348 pp., 1952.—The largest volume published by the Society, it contains 25 geological articles. Among the articles is one on the Williston Basin, with maps, two papers on photo-geology, several pool papers, articles on electrical logging, and on stratigraphy.

Starting in the February issue, Mining Engineering will carry a list of patents, issued the preceding month, on items of interest in mining and metallurgy, together with a listing of principal government publications available.



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Manufacturers News

New Products • *FILL OUT THE COUPON FOR MORE INFORMATION* • Equipment

Dragline

Reported to be the largest dragline ever mounted on a single pair of crawlers, *P&H's* new model 1855 was publicly field tested recently. Four separate Magnetorque units control every motion of the 8-cu yd

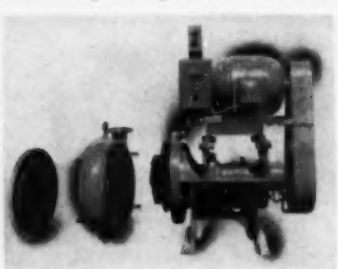
machine. Capable of handling an 8-cu yd bucket with 120-ft boom, or 7-cu yd bucket with 150-ft boom, the 600,000-lb machine has a 590-hp diesel engine. First model purchased it to be used for coal striping at Sligo, Pa. **Circle No. 1**

Geophysical Equipment

Geophysical Instrument Co., division of *Georator Corp.*, announced development of its complete Geovolt apparatus, for self-potential or spontaneous polarization prospecting. Apparatus includes Geovoltmeter, electrodes, reel, cable. **Circle No. 2**

Pumps

Vacseal solids and acid handling pumps, in rubber lined and metal types from 2 to 8 in. sizes, and in capacities up to 3000 gpm, are announced by the *Galigher Co.* These pumps operate on a patented vacuum-seal principle. Auxiliary vanes on the impeller produce a vacuum



on the shaft seal to prevent solids from cutting shaft or packing. The pumps are primarily designed for mill service handling pulp and for underground use. **Circle No. 3**

CO Detection

Capable of accurately measuring from 0 to 5 parts per 10,000 of CO in air, the *Taller & Cooper* detector has been tested and used in New York's Brooklyn-Battery tunnel. Applications for mines, as well as tunnels, garages and industrial plants are suggested. **Circle No. 4**

Gloves

After nearly 10 years of research, all-leather, heat-resistant gloves, said to be able to take temperatures up to 800°F are now distributed by *Mine Safety Appliances Co.* Available in various styles, the new gloves were designed to be durable, comfortable, economical. **Circle No. 5**

Conveyors

The *Conveyor Equipment Mfg. Assn.* has published a manual on standard nomenclature, containing about 1500 listings and line drawings of more than 80 types of conveyors and parts. Major items are given in French, German, Italian, and Spanish, as well as English. The glossary was designed to save time and money and avoid confusion for both users and manufacturers of conveyors. **Circle No. 6**

Dry Photo Copies

Compact, continuous, motor driven printer and processing unit an-

nounced by *General Photo Products Co.*, delivers finished, dry, positive copies in 28 sec. **Circle No. 7**

Truck Tires

New Fleetway tire from *U. S. Rubber Co.* is claimed to reduce road failure and give up to 41 pct more original tread miles. Four main features are reduced groove cracking, lessened sidewall checking, bronze plated bead wires, and flatter road profile. **Circle No. 8**

Drill Bits

Kennametal Inc. has released a series of case histories claiming important cost savings from use of tungsten-carbide bits, and stressing importance of close manufacturer-operator contact. **Circle No. 9**

Space Scale

Transparent template made for designers and estimators by *New-Era Products* gives fast area or volume measurement from scale drawings. **Circle No. 10**

Ultra-Speed Analyzer

Copper assays in 8 min are claimed for new *Eberbach* electro-analyzer. The single position unit has a production rate stated to equal four positions on conventional apparatus. **Circle No. 11**

Diesel Engine

Built to combine features of both high-speed automotive type and heavy, slow-speed engines, *Ingersoll-Rand* calls its TS Diesel, "a smaller, lighter, but fully heavy duty engine." It is rated 200 to 400 hp, 900 to 1000 rpm, and built with six cylinders naturally aspirated, six or eight cylinders supercharged. **Circle No. 12**

Drafting Boards

Handy idea in drafting boards from *Bradford Bailey Co.* has a

parallel rule and scale indicating amount of parallel movement. The Par-1-1-er comes in 12x13, 15x19, and 21x25-in. sizes. **Circle No. 13**

Free Literature

(14) CONVEYORS: A newly-revised 28-page catalog of Rapistan conveying equipment with photos, drawings and specifications of an enlarged line of power and gravity conveyors, hand trucks, and industrial casters has been published by the *Rapids-Standard Co.* Several new equipment models are shown for the first time in the catalog.

(15) PROTECTION: *The Gates Rubber Co.* has published a large "Handbook of Abrasion and Corrosion Protection." Flexible page numbering and loose leaf format provide for insertion of new information and new application experience. Specific topics of interest to the mineral industries are in sections on: conveyors, Fagergren parts, rubber-lined pipe, ore car liners, ball mill scoops, chute linings, sand pumps.

(16) CIRCUIT BREAKERS: A manual explaining operating principles of basic circuit breaker designs and with engineering application data has been published by the *Heinemann Electric Co.*

BIGGEST BLAST ever set off on a highway construction project, according to reports from South America, it threw up a cloud like an atomic explosion and crumbled 390,000 cu yd of rock on the Caracas to Puerto LaGuaira highway in Venezuela. Gardner-Denver drills and ten of their 500 cfm portable compressors helped prepare for the blast.

(17) SAND PUMPS: *Denver Equipment Co.'s* SRL sand pumps are described in a booklet illustrated with cut-away views, and including pulp density tables, pump capacity charts and motor selection tables.

(18) BLASTING: Blasting machines and short-period delay electric blasting caps are discussed in two informative pamphlets issued by *Hercules Powder Co.* Wiring hook-ups and delay applications are given in both text and illustration.

(19) VOLTAGE STABILIZERS: Automatic voltage stabilizers ranging from 15 to 5000 volt-amperes capacity are topic of a *General Electric Co.* booklet. Causes and effects of voltage variation are described.

(20) CRUSHING - SCREENING - WASHING: *Pioneer Engineering Works* has issued a new 16-page catalog on "Basic Units" for crushing, screening and washing plants.

(21) ROTARY DRILLS: A booklet from *Joy Mfg. Co.* tells the story of their Champion rotary air-blast drills. Joy Champions are continuous-type rotary drills, operating dry with compressed air blast for cuttings removal.

(22) CENTRIFUGAL PUMPS: *Allis-Chalmers* has released a "Handy Guide to Selection of Centrifugal Pumps," covering a wide range of pump types for mining use.

(23) WIRE ROPE: Specification data on most-used varieties of Tiger Brand wire rope, made by the *American Steel & Wire Div., U. S. Steel Co.*, are covered in a ready-reference manual.

(24) HEAVY DENSITY UNITS: Recently introduced H-D units from *Wilmot Engineering Co.* are described in a new bulletin. It features flow diagrams for various feeds with illustrations and engineering and specification data. Nine standard sizes from 50 to 800 tons per hr are available. Six standard types of plant arrangement are illustrated in the bulletin.

(25) STORAGE BATTERIES: Economies from lower first cost, increased efficiency, and longer life are claimed for a new series of Exide-Manchex batteries in transparent plastic containers. Typical two-cell end-to-end assembly of the

new type CME *Electric Storage Battery Co.* unit is shown in the cut-away illustration. An 8-page booklet and data sheet provide full details.

(26) HOOK-ON INSTRUMENTS: New 8-page booklet describes *General Electric's* hook-on ammeter, wattmeter and power factor meter.

(27) POWER HAMMER: A release from *Barco Mfg. Co.*, "A profitable Tool of Many Uses," describes applications for their portable gasoline

powered hammers. Illustration shows Barco hammer driving wood sheathing on construction job.

(28) COMPRESSORS: *Joy Mfg. Co.* has issued specifications on a line of oil-free, non-lubricated compressors of 172 to 8800 cfm capacity, 25 to 600 hp, for applications requiring uncontaminated air.

(29) ION EXCHANGE: One of the fields in which ion exchange holds great promise is in the recovery of valuable metals. Information on the subject is contained in a 9-page reprint of a talk, "Metal Recovery by Ion Exchange," given by C. F. Paulson of the *Permutit Co.* Tables charts, and other data illustrate some of the forms in which industrially important metals are present in solution and how they might be economically recovered.

(30) TIRES: A 12-page industrial tire guide book has been released by the *B. F. Goodrich Co.* which shows the complete industrial tire line, the service in which each tire should be used, and contains many useful maintenance tips on tire care.

Mining Engineering **January**
29 West 39th St.
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Rod Deck

Gives You These 3 Big Advantages

SCREENS

LESS BLINDING! Sticky materials go through slotted openings between rods with less trouble than through conventional wire cloth or perforated plate. Rods provide a positive cutting action.

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LONGER LIFE! Rod deck design permits using heavy ⅜ to ½ in. rods. The rod deck costs less to operate than a conventional screen — you need only replace worn rods, not an entire screen surface.

MONEY-SAVING APPLICATIONS

- For scalping ahead of crushers.
- Preparing grinding mill feed.
- To replace conventional double deck screen. Rod deck requires less head room, reduces operating cost, handles larger size feed.
- Any screening operation where square separation is not necessary.

Ripl-Flo is an Allis-Chalmers trademark.

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Find out how rod deck screens can cut costs and reduce downtime in your operations. Call the A-C representative in your area, or write to Allis-Chalmers, Milwaukee 1, Wisconsin.

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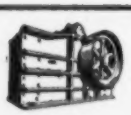
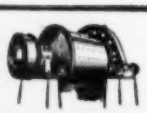


Jaw Crushers

Gyratory Crushers



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COPPER-MOLYBDENUM-ALLOY

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Used and PROVED Around The World

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THE LARGEST known copper orebody in the world, will produce more than 300 million pounds of blister copper a year, and treat 30,000 tons of ore a day. The Anaconda workings are a landmark in mining operations.

SHEFFIELD MOLY-COP GRINDING BALLS play a vital role in this record-breaking project. Their longer service in the new sulphide concentrator means lower grinding costs, fewer chargings, and less "down time."

SUPERLATIVE PERFORMANCE of Sheffield Moly-Cop grinding balls is the result of years of research, and quality-controlled methods of manufacture—from initial alloy steel production to final heat treatment.

LET SHEFFIELD prove how Moly-Cop Grinding Balls will do a better job for you.

SHEFFIELD STEEL CORPORATION

HOUSTON KANSAS CITY TULSA

SUBSIDIARY OF ARMCO STEEL CORPORATION

Export Representatives: ARMCO INTERNATIONAL CORPORATION, MIDDLETOWN, OHIO

This 11½ x 12 ft. Ni-Hard Lined Rod Mill replaced 2 sets of 74" x 20" rolls with accompanying screens and conveyors for handling lead and zinc sulphide ore at the Sullivan concentrator of THE CONSOLIDATED MINING & SMELTING COMPANY OF CANADA LIMITED. (Balls placed to show size and spacing of liners are 3" in diameter.) This mill, which operates with a 76-ton charge of 3½" rods and is designed to handle 400 tons of ore per hour, is a product of the HARDINGE COMPANY, INC., York, Pa.

Four-years' service indicates 6,750,000-ton life for Ni-Hard liners in world's largest rod mill

Performance Records Prove It: NI-HARD® *provides abrasion-resistance at lowest ultimate cost...*

And the reason? With a matrix resembling that of fully hardened steel, this moderately priced nickel-chromium white cast iron is the most abrasion-resistant product of the foundry industry.

Shown in the Hardinge Rod Mill, above, are the original Ni-Hard shell and discharge end liners. The end liners are still in use and after four years of milling approximately 8,000 tons of ore per operating day, it is conservatively estimated that their total life will approximate 6,750,000 tons. The shell liners were replaced after a life of 5,700,000 tons. The probable total consumption for both shell and end liners will reach the extremely low figure of 0.010 pounds per ton.

Take steps, now, to save labor and cut maintenance as well as operating costs by using Ni-Hard for your equipment parts subject to wear and abrasion. Our wide practical experience, gained over the past 20 years in the Ni-Hard field, is available to help you determine *whether or not* Ni-Hard is the best answer to your particular needs. Send us details of your problems for our suggestions. Write us now.

At the present time, nickel is available for the production of Ni-Hard and other alloys containing nickel, for end uses in defense and defense-supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

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THE INTERNATIONAL NICKEL COMPANY, INC.
Dept. 20, 67 Wall Street, New York 5, N. Y.

Please send me free booklets entitled: "Engineering Properties and Applications of Ni-Hard" and "Buyers' Guide for Ni-Hard Castings."

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Plans for a multi-million dollar uranium mill in southeastern Utah were confirmed by Vanadium Corp. of America officials. Atomic Energy Commission has been dickering with two private firms for mill construction at Hite, Utah and Shiprock, N. Mex.

Colorado Fuel & Iron has contracted to purchase all manufacturing business, plants and inventories of John A. Roebling's Sons Co., through a wholly owned subsidiary. CF&I currently the nation's ninth largest steel producer, will operate the new subsidiary under the Roebling name.

A Canadian newspaper, the Toronto Telegram, carried a million dollar rumor involving Inland Steel Co., of Chicago and Steep Rock Mines, Ltd. It is reported that Inland is willing to pick up an option on an 800-acre tract of Steep Rock property. Inland is further reported ready to start drilling when ice on Steep Rock Lake freezes over.

Link-Belt Co. has started fabrication of parts for a conveyor system to be installed as part of the ore handling system for a Venezuelan iron ore mining project. The system which will unload, crush, screen, and store ore at a 6000-long-ton-per-hr rate is being manufactured at Link-Belt Co.'s new Colmar, Pa., plant. Reported as a possible incorporation in the system, is a television system, designed to aid dockside loading operations.

Eastern Kentucky coal mines are reported hard hit by the wage boost recently gained by John L. Lewis. Six big mines have closed down in the past three months, with more than 1200 men out of work. In addition, several smaller mines have ceased operation. Defections also have arisen in the ranks of the Bituminous Coal Operators Association. Illinois and Indiana strip mine operators' associations have withdrawn from the larger group.

Big steel closed out a momentous quarter as U. S. Steel poured its billionth ton of steel at Homestead works, Pittsburgh and announced appointment of Clifford F. Hood as new president. (See Trends). First blast furnace went into operation at the new Fairless works in December.

Winter iron ore supply levels, seriously endangered by the steel strike, were reached through an unprecedented late shipping close-down on the lakes. A monumental all-rail haulage program was cancelled when ore boats passed 75 million ton goal.

Housing and other facilities for native employees of Northern Rhodesian copper mines will be improved under a £ 2 million program. Companies concerned are Mulfulira Copper Mines, Ltd., Nchanga Consolidated Copper Mines, Ltd., Rhokana Corp., Ltd., and Roan Antelope Copper Mines, Ltd.

Permutit Co. has placed contracts for a new laboratory and pilot plant building at an approximate cost of $200,000. Further expansion comes on the heels of completion of the 1952 program doubling capacity of Permutit's output of ion exchange resins at its Birmingham, N. J. works.

Replaces 7 trucks with 2 Tournarockers on tough coal stripping job

Portion of haul road, showing deep standing water . . . with soft, rutted incline in the distance. Hauling under these tough conditions, the 2 Tournarockers totaled 4,000 hours with 95% mechanical efficiency.

With heaped load, Tournarocker starts 300' haul to fill. Rig's ability to turn 90° in 13'9" radius speeds cycle. Says Owner Chapman: "One feature we particularly like about these machines is the way we can turn them around without stopping in our narrow cuts."

H. T. Chapman **of Elkins, West Virginia — stripping 1,500,000 yds. of shale for the Phil Williams Coal Co. near Elkins — has a serious haul problem on his hands. During much of the year working conditions are very bad. Steady rains, combined with poor drainage, continually saturate haul roads and material. At times, parts of the haul must be made through 30" of water. Access roads are wet, spongy, and practically bottomless in places.**

"Only equipment that can do job"

When it became apparent that dump trucks couldn't work efficiently under these conditions, Chapman tried 2 rear-dump C Tournarockers. With their traction advantages—front-wheel drive, big high-flotation tires and power-proportioning differential (which automatically applies up to 4 times the power of slipping drive-wheel to wheel on firmer ground) — these rigs really did the trick! After several months' use Chapman observed, "Tournarockers are the only pieces of equipment that could do the job. My 2 'C's' have replaced 7 trucks!"

Move 220 yds. of overburden hourly

Company records covering several typical months of stripping show the 2 Tournarockers average 11 cu. yds. (almost 15 tons) of hard blue shale per load. On a soupy 600' cycle, each rig makes 10 trips per hour . . . hauls 1100 yds. (1500 tons) per 10-hour day.

Also haul coal, 22 yds. per load

The 2 "C's" have also been used to haul coal. On this work, they move about 22 cu. yds. per load. Average 12,000' cycles are completed every 15 to 20 minutes — in spite of travel through 800' of belly-deep mud, up 700' of 16% unfavorable grade and down 200' of 30% favorable grade. That's 3 to 4 trips (66 to 88 cu. yds.) per hour for each rig.

Whenever *you* have coal, rock, ore, or other shovel material to haul, it will pay you to check the output of fast rear-dump Tournarockers. Write for complete facts and figures on work like yours. We'll be glad to arrange a demonstration for you at your convenience.

LETOURNEAU LET EQUIPMENT

R. G. LeTOURNEAU, INC.

Peoria, Illinois

Tournarocker is shovel-loaded with 11 yds. (15 tons) of well-blasted shale. About 10% of chunks are too big to clear 2-yd. bucket. Note restricted loading area. Rig's low, wide, open bowl makes easy shovel target . . . speeds loading, boosts daily output.

At fill, Operator Dayley Collett backs Tournarocker to edge of bank, flips fingertip "dump" button, drops load clean over bank. Reports Collett, "What I like most is the easy way these Tournarockers handle. They turn around with plenty of room to spare."

Tournarocker—Trademark Reg. U. S. Pat. Off. R-221-CM

A Cost-cutting team

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AND ITS SUBSIDIARY COMPANY **COLORADO IRON WORKS CO.**

Denver 2, Colorado

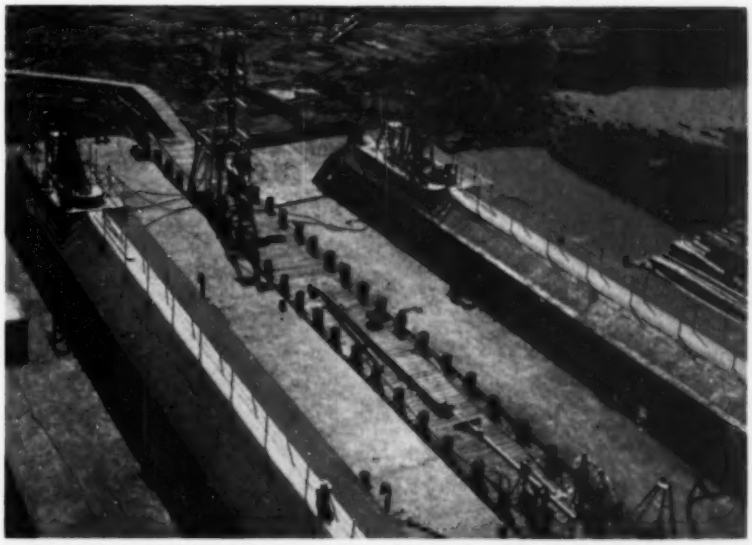
Freeport's Floating Mine Begins Sulphur Operation

Eight years of research were culminated when Freeport Sulphur Co.'s floating mine plant went into operation on Bay Ste. Elaine in the remote Louisiana bayou country 60 miles southwest of New Orleans.

Freeport expects to produce about 100,000 long tons of sulphur from the deposit. The 200-ft steel plant barge was developed because of the prohibitive cost of a permanent installation. Resting on an oyster shell base laid on the bottom of the bay, the barge is anchored to piles driven into the earth. Shops, warehouses, and offices are also on the barge.

Two million gal of water, at 325°F are furnished from the plant every 24 hr. Electrically operated valves and telemetering devices regulate and register the amount of water entering the deposit. Molten sulphur is pumped into tank barges for transport to Port Sulphur. Sea water is used in the mining operation for the first time.

Governor Frederick Payne, of Maine, in the meantime, said that Freeport has been investigating recently discovered sulphur deposits in his state. A Freeport official, however, is reported to have stated that his company has no immediate plans for development. The Maine deposits consists of pyrite ores similar to those treated in Spain.



Two insulated tank barges take on molten sulphur at Freeport Sulphur Co.'s operation at Bay Ste. Elaine in the Louisiana Marshland. Sulphur is being mined from the deposit with a barge-mounted plant. Tanks carry 1000 tons of sulphur at nearly 300°F.

Youngstown Steel Firms Consider Coal Pipe Line

Pipelining coal to Youngstown, Ohio, steel plants is being considered as a means of overcoming cost factors in competing with plants in other districts having cheap water transportation.

Youngstown, the biggest steel district without convenient water transportation, is said to be under a $4 to $5 disadvantage in costs of gathering raw materials. Experts claim this to be one of the factors holding back large scale expansion in the Youngstown area.

Extending 35 miles between the Ohio River at East Liverpool and Youngstown, the line would cost an estimated $6 million to $7 million, but might return a saving of 50¢ to $1.00 on rail coal rate of $1.50 a ton.

A new company, Hydrocoal Transportation Co., has been organized by the Mahoning Valley Industrial Council, and is underwriting numerous engineering studies. M. A. Hanna Co. has been experimenting with a coal pipe line at Georgetown, Ohio.

Coal would be crushed to sizes used by coke plants or for firing boilers, washed, mixed with river water to form a sludge, and then pumped by strategically located stations to Youngstown. It would then be dried for use. A big cost factor is drying the coal at a mine washery and again at Youngstown.

Israeli miners perform preliminary surface work at the site of King Solomon's copper mines. Surface outcroppings are completely oxidized. Armed guards look on as copper is taken from the earth in Israel for the first time in 3000 years.

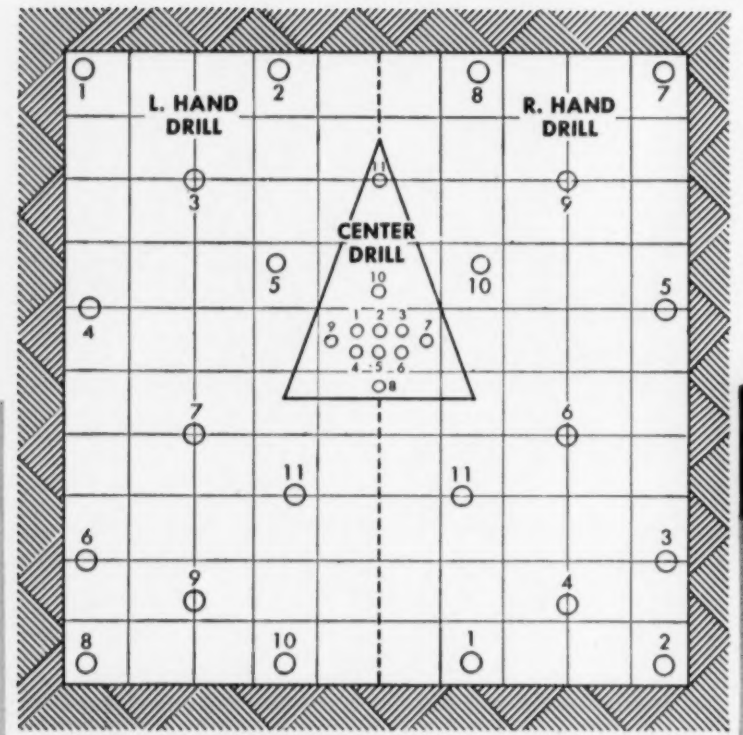
J & L Sells Carriers

Jones & Laughlin Steel Corp. has sold its four Great Lakes ore boats to Wilson Transit Co., Cleveland, the firm which has carried a large portion of J&L's ore for several years.

The boats to be officially transferred at the end of the Lakes shipping season are the B. F. Jones, James Laughlin, Willis L. King, and Thomas Walters.

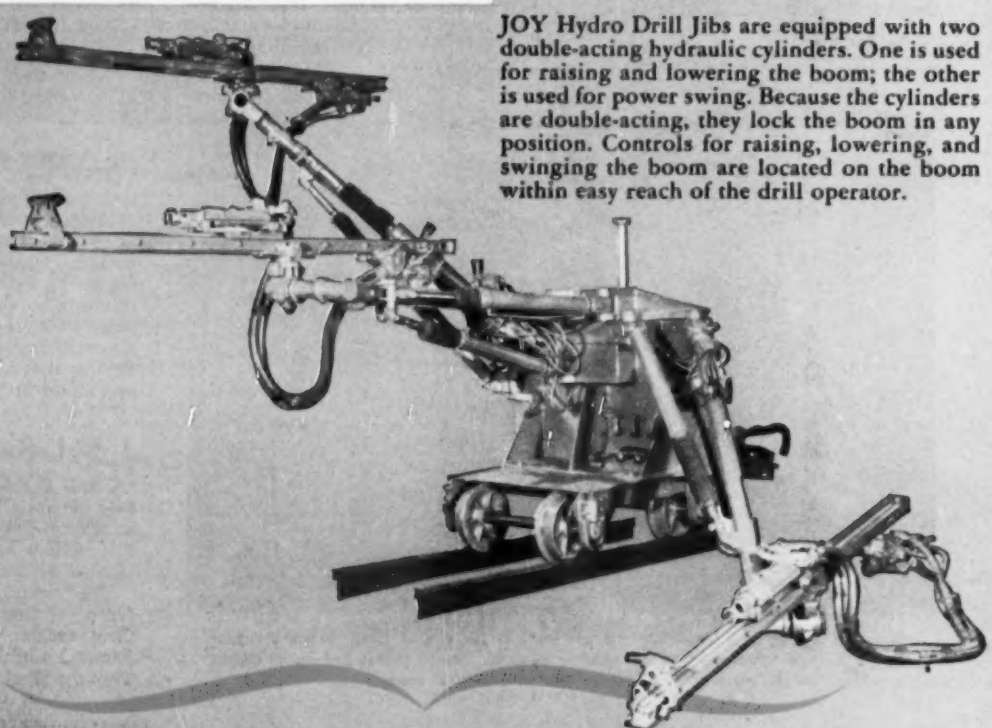
"DRILL OUT THIS ROUND"

said the Joy Engineer.



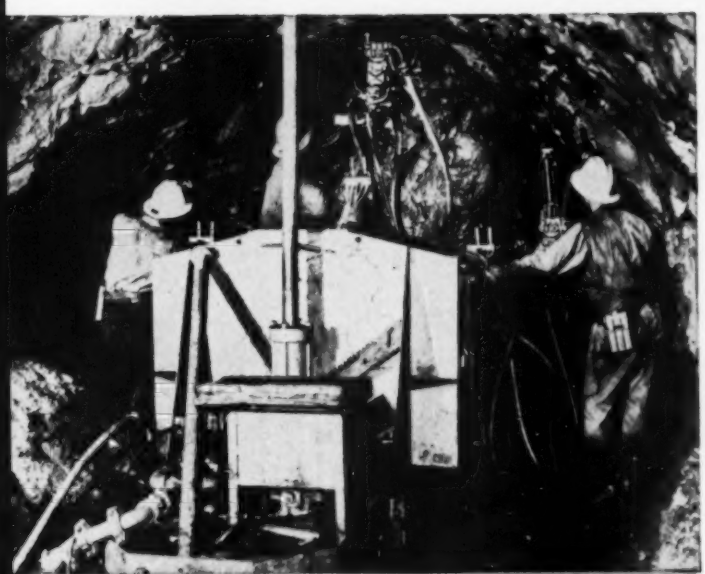
JOY Hydro Drill Jibs are equipped with two double-acting hydraulic cylinders. One is used for raising and lowering the boom; the other is used for power swing. Because the cylinders are double-acting, they lock the boom in any position. Controls for raising, lowering, and swinging the boom are located on the boom within easy reach of the drill operator.

MAXIMUM VERTICAL RANGE WITH VARIOUS LENGTH BOOMS: 10 to 14 FEET

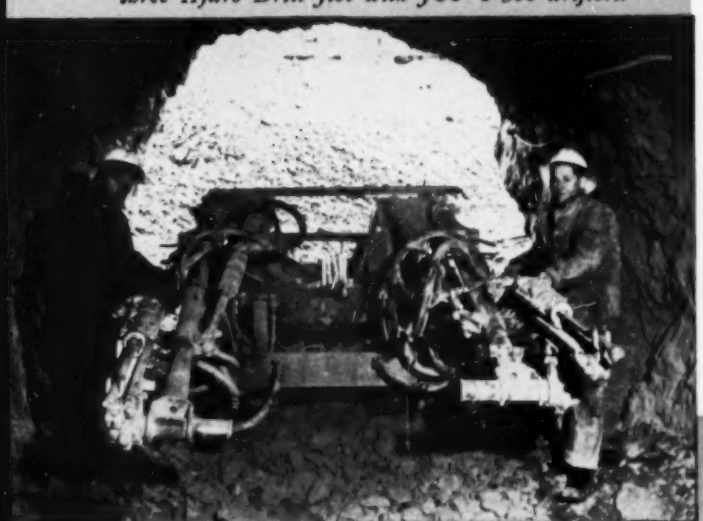


MAXIMUM LATERAL RANGE WITH VARIOUS LENGTH BOOMS: 18 to 28 FEET

"IN RECORD TIME and WITH LESS EFFORT with JOY HYDRO DRILL JIBS"



On the job in a heading: a JOY Jib Jumbo mounting three Hydro Drill Jibs with JOY T-300 drifters.



JOY builds a complete line of Jib Jumbos and Drill-mobiles. Above: a twin-boom JOY Drillmobile, rubber-tired and self-propelled for quick, easy mobility.

The recommendation above was made by one of Joy's drill mechanization specialists. He made it to a mining company which is now a satisfied user of the equipment recommended: four Joy Jib Jumbos (see facing page) each mounting three Joy T-300 Drifters on LW-6A long chain feeds. He went on to say—

"The LW 6A feed, easily supported by the Hydro Drill Jib, has an overall travel of 8 feet with a steel change of 6 feet. Thus, the proposed round can be drilled with one length of steel."

He then proposed and fully explained a drilling pattern (again see facing page) for a 10′ x 10′ round, showing the location of the eleven holes to be drilled by each one of the three jib-mounted drills. Basically, the plan provided for the least interference, and the maximum amount of drilling without dumping or swinging the drills. The holes for each drill were numbered so that the spreads between gave the runners plenty of working room. He closed by saying—

"The purpose of this proposal is to describe the many advantages of Joy fully automatic Hydro Drill Jibs. Joy pioneered the hydraulic drill jib and is still maintaining the lead in the design of this type of rig. We are keeping ahead with sound, practical improvements, and today believe we produce the finest drilling equipment available."

● Why not let a Joy drill mechanization specialist look over your problem and solve it the way he did this one? *Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa. In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

Consult a Joy Engineer

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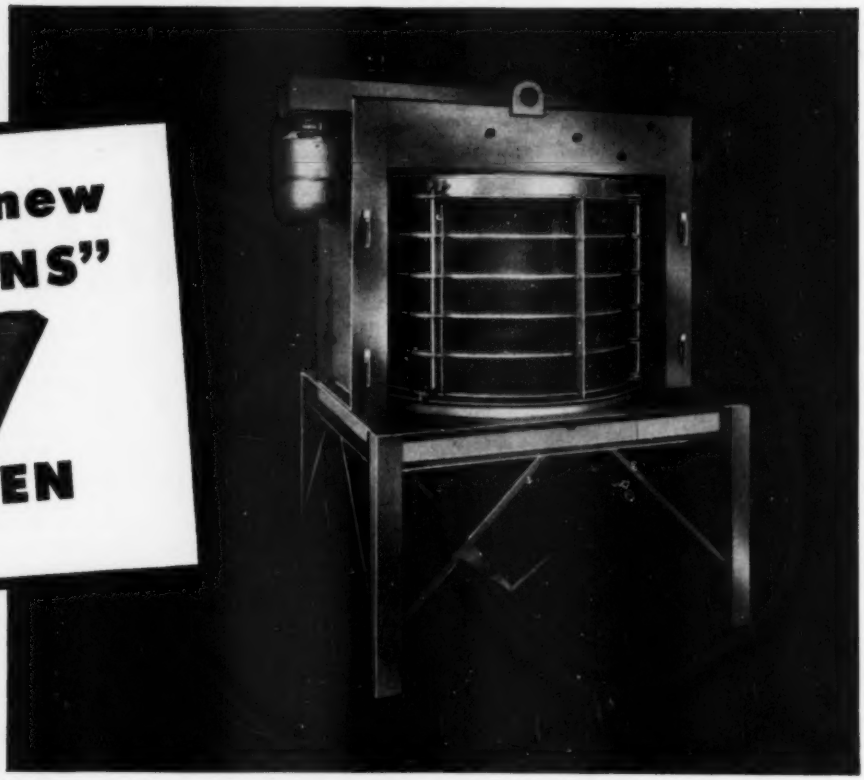
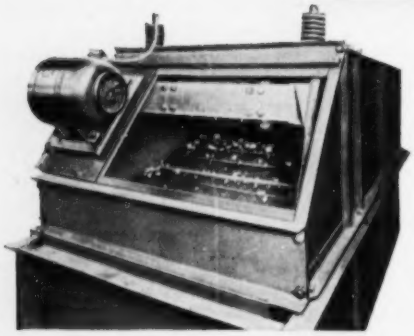
...the new "SYMONS" V SCREEN





"SYMONS" ROD DECK SCREEN . . . employs a highly efficient screen deck, utilizing individual replaceable spring steel rods. Features low screening cost—big capacity—low maintenance—long life—ideal for moist and sticky materials.

THE "SYMONS" V (vertical) Screen is the newest addition to the well-known line of "SYMONS" Screens . . . and provides extremely fine, single cut wet or dry separations.

Revolutionary in design, and operating with a combination of centrifugal action and gyratory movement, this new screen has proved ideally suited for sand, gravel and crushed stone plants—metallic and non-metallic mining—chemical plants—cement plants—coal preparation plants—and scores of other industrial applications.

Requiring a minimum of floor space, the "SYMONS" V Screen is easily installed, and provides fully enclosed construction to assure dustless operation—yet access to the screen is simplified through easily removable covers. *Write for further details.*

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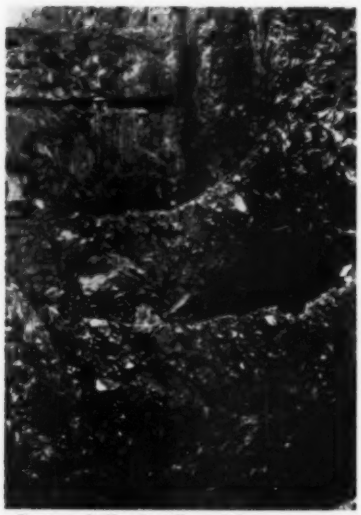
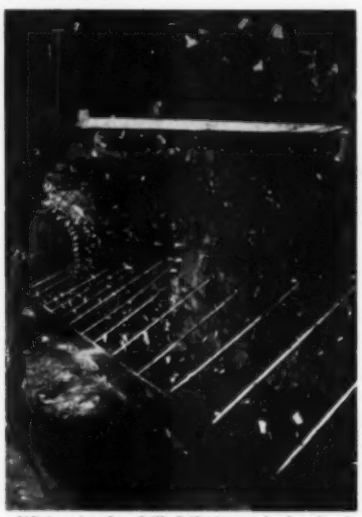
"SYMONS" Vibrating Bar Grizzlies and Screens

Diesel Engines

Inco Sets Off 64-Ton Blast at Frood-Strobie Mine



Bottom half of pillars left as support while stopes were mined out before blasting. Floor of the open pit is visible at top of photograph.



Wiring in the drill drift is ready for final hook-up to the blasting circuit. Leg wires from the down holes are supported clear of wet ground by wooden sticks.

A wooden model in longitudinal section was used to plan the record blast. Darkened part of the model represents ore.

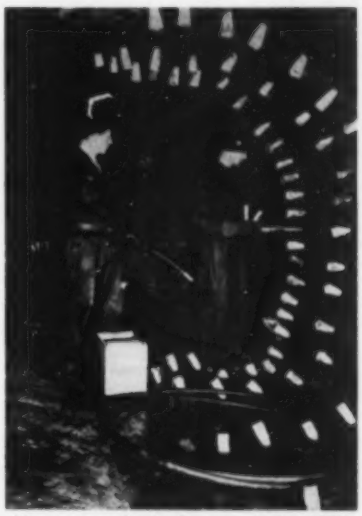
SIXTY-FOUR tons of explosives went into the biggest single blast in the underground mining program of International Nickel Co., of Canada, Ltd., reducing two giant blocks containing 400,000 tons of nickel-copper ore.

Some 2000 blastholes were drilled. Only a muffled explosion was heard as the climax to months of planning. The blast was the second of its kind at Frood-Strobie and another step in the process of conversion to all-underground mining operations. It took place above the 600-ft level, below the area where surface mining has been concluded in the south end of the open pit.

Four big blasthole stopes were mined through from the 600-ft level of the mine to the pit floor. The top half had been removed from two pillars of ore left as support while the stopes were being mined. Each pillar stub measured 70 ft in width, by 150 ft in height, and 200 ft in length. Accurate timing of the mining cycle permitted loading of rings of holes in newly drilled pillars as the last of the previously broken ore was removed.

Ore was driven through drawholes in the bottom of the stopes to slusher trenches and then to ore passes leading to loading chutes on the 1000-ft level. Ore was hauled in 15-car trains to a rotary tipple and put through a crusher. It was then hauled by skip to the surface.

Meanwhile, drillers were busy in tunnels driven across the bottom half of the two pillars. Each ring contained 19 holes, each 1½ in. loaded with 75 pct Forcite powder primed with an electric detonating cap followed by two or three more sticks of powder and a stick of clay. Leg wires were connected in groups of 43 and hooked up in parallel to main blasting wires, which were carried 90 ft up to the service raise, from the sub-level where the drilling tunnels were located up to the 400-ft level. Shot was fired with four locomotive batteries. *(Frood-Strobie Mine described in detail, starting on page 57, this issue)*



Miner on right loads one of the 2000 holes drilled for the blast. His companion holds a hollow plastic loading stick, with a wooden plug, used to tamp holes.

After the blast, ore dropped into three stopes formerly separated by the pillars. Horizontal recesses in upper left formed part of tunnels drilled for previous blast.

Four locomotive storage batteries connected in series on 400-ft level provided a 400-v jolt for the record 400,000-ton blast. Main blasting wires from drill drifts were brought up through service raise from 6.1 level.

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APPROVES STEARNS MAGNETIC SEPARATOR

— FEATURES —

- Lowered treatment cost due to highly efficient recovery
- Continuous, automatic recovery during fluctuating feed conditions
- No possibility of short circuits as air cooled magnet is suspended completely above water bath
- Test results indicate improved overflow weir action results in less media loss in overflow discharge
- Action of separator is visible to operator at all times
- Simplified operation
- Shipped complete, ready to install. No additional feeders or extensive piping necessary

AFTER completely satisfactory performance at the American Zinc Company plant at Mascot, Tenn., The American Cyanamid Company, as technical representative of the American Zinc, Lead & Smelting Company, has approved the STEARNS Type "MWI" Magnetic Separator for use in Heavy-Media plants. In operation in the Heavy-Media process in the concentrating of zinc ore, the STEARNS Type "MWI" Separator recovered better than 99.9% of the magnetic ferrosilicon.

The STEARNS Type "MWI" Magnetic Separator is equally adaptable for the recovery of media in Heavy-Media plants for the processing of all types of ores. This includes iron ores, fluorspar, rock products, coal, and similar materials. Specialized STEARNS Magnetic Separators are available for the recovery of other media such as magnetite.

Whether your problem is that of purification, reclamation, or concentration, STEARNS has a separator for you. From the fairly simple job of tramp iron removal to the concentration and beneficiation of complex ores, STEARNS has EXPERIENCE ENGINEERED equipment to meet your specifications.

Complete laboratory research facilities are available for thorough investigation of your separation problem. This includes a complete analysis of the practicability of applying magnetic separation, the testing of sample material, and the recommendation of specific magnetic separation equipment.

Foremost in the Magnetic Field

Stearns MAGNETIC INC.

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Reynolds Metals Buys Guiana Bauxite Properties

Reynolds Metals Co. has purchased the Berbice Co. Ltd., British Guiana subsidiary of American Cyanamid. Sale includes three mining leases totaling 6254 acres, a 99 year lease on a 2040-acre plant site and 482,210 acres with permission to explore and acquire additional mining leases.

In addition to plants, machinery, and transportation equipment, purchase involved an ore stockpile containing about 58½ pct alumina. Walter L. Rice, president of Reynolds Mining Corp., said that Reynolds has entered into a 29-year contract to supply alumina requirements to Anaconda Copper Co. The British Guiana purchase is expected to assure a substantial part of bauxite needed for this contract.

In the meantime, Reynolds announced that the official opening of bauxite mining operations at Ochos Rios, Jamaica will take place during the first part of January. Reynolds Jamaica Mines, Ltd., has completed installation of mining equipment, and will mark the opening with appropriate ceremonies.

I M & C Announces New Potash Process

Development of a new ore beneficiation process applicable to potash and phosphate, and other ores, was announced by International Minerals & Chemical Corp.

Neither reagents or water is used in the process, which is described as a dry beneficiation method. Named the LeBaron-Lawver process, ore is ground, dried, and given a "simple and inexpensive treatment." Ground ore is then passed between electrodes, in what is probably an electrostatic separator, and is separated into its various minerals.

Louis Ware, president of International Minerals, announced that a new and larger pilot plant will be constructed at the Carlsbad refinery for continuous use of the new process on semi-commercial quantities of potash.

Plans are also being developed for another shaft and mine on International's new orebody in the Carlsbad Basin. In addition, designs are near completion for constructing the first large potash unit in that area which will utilize the new process.

Directing the project which uncovered the new process were Paul D. V. Manning, International vice president in charge of research, and I. M. LeBaron, director of International's research laboratories. James E. Lawver and others on the research staff were also involved.

Canada to Increase Gold Mining Subsidy

Canada, in an attempt to stop gold mine closings, will tap its treasury for an additional $4 million a year to raise subsidies to the nation's gold mine operators.

Spiraling costs and low returns have resulted in great hardships. Legislation to simplify the payments program will be introduced during the current session of the House of Commons, according to Finance Minister Douglas Abbott. Effective January 1, the subsidy increase will average about $1.00 per fine ounce of gold produced, increasing average government payment from $2.80 to $3.80 per fine ounce.

If the Canadian dollar maintains its current level, the increase should give producers about $38.00 per fine ounce in 1953, slightly below the $38.50 received when the Canadian dollar was set free in 1950.

Newmont Has Option On New Nickel Company

Newmont Mining Co. has an option for a 51 pct interest in a new company being formed to exploit a nickel-copper deposit in British Columbia, about 100 miles east of Vancouver.

Pacific Nickel Mines, Ltd., will be the other participant in the new organization, Western Nickel Co., Ltd. Newmont will have no interest in Pacific Nickel. Newmont performed preliminary exploration work on the proposed project some time ago. Newmont reportedly may advance $675,000 for the second stage of exploration work. Both Newmont and Pacific Nickel will put $125,000 into the new company. The plan awaits approval of Pacific Nickel stockholders.

Utah Construction Signs Peruvian Iron Ore Pact

Peruvian embassy officials in Washington announced that Utah Construction Co. of San Francisco has signed a contract with the Santa Corp., wholly-owned government firm, for iron ore development in Peru.

Machinery for a steel mill is being purchased by Santa from French and Norwegian firms with $10.5 million borrowed from European banking interests. According to Senor Carlos Gibson, commercial secretary, the contract between Santa and Utah guarantees the Santa Corp. sufficient ore for the mill below the world market price, and a royalty for all exported tonnage. The mill will have a capacity of 50,000 tons.

I M & C Announces Building on Sand

International Minerals & Chemical Co.'s new phosphate chemical plant at Bonnie, Fla., is being constructed on dry wasteland sands, and perhaps may be the first such construction utilizing hitherto economically unattractive sand areas.

Basic to building on sand is a new process invented by Sergey Stuerman, called Vibroflotation, being handled by Rust Engineering Co. The plant at Bonnie is scheduled for completion during 1953 at a cost of $12 million. A saving of about $250,000 in construction by use of the sand compaction practice is reported.

Ky. Coal Mine Begins Production in 1953

Nashville Coal Co. expects to have its new $8.5 million mine plant now under construction at Uniontown, Ky., in full production this year. It will raise the firm's rated capacity at its eight mines to 8,643,000 tons annually.

About a mile of conveyor belts will be used from the bottom of the slope to the banks of the Ohio River, where the coal will be loaded on barges. Facilities capable of loading 1200 tons per hr are being installed.

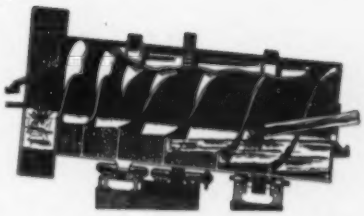
Mine construction will cost about $4 million and produce about 2 million tons of coal annually. Barge equipment is estimated to cost about $2.5 million.

3-Purpose Mining Machine Raises Output

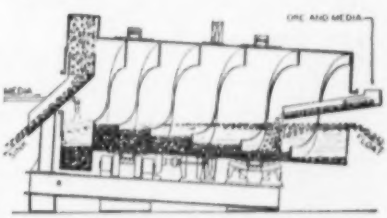
A machine which has boosted production at American Zinc, Lead, & Smelting Co.'s Grandview mine, near Metaline Falls, Wash., from 14 tons per man-hr to 81 tons performs the work of three separate pieces of equipment.

Nicknamed the *Gismo*, the machine drills blasting holes, scoops up the ore, and finally carries it away, according to Dale I. Hayes, western manager for American Zinc, and its developer. Looking like a huge dump truck mounted on tractor treads, the *Gismo* has a big dipper mounted on front. It is tractor-hauled to the ore-chute, where it dumps its load automatically. Twenty minutes are required to convert the machine to drilling, using a permanently mounted 160-lb crane.

The inventor claims that the machine can be taken underground. Size can be modified to fit space limitations.



COUNTER-CURRENT HEAVY-MEDIA SEPARATORS



The Hardinge Counter-Current Heavy-Media Separator is a slowly-revolving, inclined, cylindrical drum with spiral flights attached to the inner surface of the cylinder. As the drum rotates, the "sink" is carried by the spiral flights to the high end. The "float" overflows a circular weir at the lower end.

Repeat orders are coming in—the best endorsement of all! Bulletin 39-B-2.

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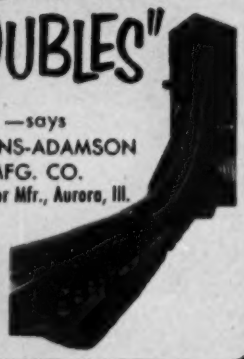

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REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

Noranda Gets $30 Million For Cu-Zn-S Projects

Noranda Mines, Ltd., announced financing arrangements for $30 million. Privately placed debentures brought in $20 million and bank credits provided another $10 million, assuring funds for three new projects.

Gaspe Copper Mines, Ltd., of which Noranda holds 93 pct, reportedly has 70 million tons of 1½ pct copper ore. Plans call for a 6500-ton-per-day plant. Production, scheduled for 1954 or 1955, hinges on hydroelectric power, to be delivered by cable under the St. Lawrence River. Process details for Gaspe have not been announced, but Chemico's chemical process for metal recovery is hinted under consideration.

Chemical Construction (Inter-American) Ltd., is building Noranda's new $4 million sulphur recovery plant adjacent to North American Cyamamid's Welland, Ontario, operation. Pyrite concentrates from Noranda will be processed at the rate of 350 tons per day to yield 54,000 tons of sulphur annually, one third as elemental sulphur.

Two thirds of sulphur plant output will be piped to Cyanamid's operation as sulphur dioxide for sulphuric acid manufacture. About 75,000 tons of iron sinter will be available for Canadian Steel use annually.

Third project involves a zinc-pyrite operation. Noranda has 51 pct interest in a new company bringing Rouyn district property, purchased from MacDonald Mines, into production. Plans call for a 1500-ton-per-day mill, with $3.5 million outlay.

National to Build Biggest Ore Carrier

National Steel Co., already owners of the largest ore carrier on the Great Lakes is reported to have made an oral agreement for another carrier even bigger.

The craft will be built at the Lorain yards of the American Shipbuilding Co., builders of National's E. T. Weir, the largest ore carrier presently afloat on the lakes. The new carrier will cost an estimated $6 million.

White Pine to Build Water Pumping Station

A pumping station to service the town of White Pine, and the new copper mine plant there will be constructed six miles away at Silver City, Mich., by White Pine Copper Co. Silver City is located at the mouth of Big Iron River.

The company plans to sink a shaft to a point 80 ft below low-water datum of Lake Superior. An intake tunnel about 3500 ft in length will be excavated through shale rock at the bottom, extending lakeward.

Report Falconbridge Seeks Second Loan

Falconbridge Mining Co., Ltd., of Canada, created a certain amount of conjecture in Washington recently, when the firm applied for a new loan from the Export-Import Bank.

It was felt that the loan might be used to develop the new Fecunis Lake orebody where drilling is now going on. Construction work was delayed by setbacks in equipment deliveries for the concentrating and refining plants. Good progress is now reported.

Falconbridge was granted a loan of $5 million from the Export-Import Bank in October, 1952. Current production is rated at about 23 million lb of nickel, with the possibility that expansion plans may raise output to about 35 million lb by 1954.

No indication of how much money the Canadian firm wants has been given. Bank and mining company officials have been engaged in exploratory talks.

Britain to Exploit Gold Coast Bauxite

Britain is taking steps to exploit West African Gold Coast bauxite deposits, according to a white paper presented to Parliament by the Government. Total investment envisioned by the white paper is about $403.2 million.

Involved in the plan is a hydroelectric power project on the Volta River to produce a continuous 560,000 kw. Smelting plant facilities to produce 120,000 long tons of aluminum annually are planned.

Construction of new port facilities at Tema, new rail lines, highways, schools, and housing is also anticipated. No production is expected for five years, with maximum output to be reached in about 20 years.

It has been reported that Aluminum Co. of Canada, Ltd., is interested in the project. Financing, as outlined in the white paper would be by Britain, Gold Coast Government, and private interests.

Southern By-Products Corp. Opens New Mine

The first new commercial coal mine in Alabama in years will be opened by the Alabama By-Products Corp. at Maxine in West Jefferson County at a cost of more than $3 million.

Three companies, Alabama Power Co., Georgia Power Co., and Gulf Power Co., will take most of 1 million tons annual production.

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You Can't Beat an Eimco

Above: Digging ditch beside highway in Canada. Below, left to right: Clearing rock off highways, taking out shoulder for highway widening, loading in a tunnel, loading trucks in rock quarry.

Is Big Business Bigger?——*Land Grabbers*——*Copper Controls*

AN economist at MIT provided Americans with myth destroying information which should prove effective against the *gentlemen* of the extreme left. For a number of years they have charged that a small number of companies in each industry has been grabbing more and more of the industry's business. M. A. Adelman has shown that the concentration of business in the hands of big corporations has not shown any sign of growth during the last 50 years. Quite the contrary, there has been a slight decline in this concentration, according to Adelman. There are more small companies per thousand population than ever before.

Bearing this out is the fact that International Harvester is now doing 41 pct of the possible market against a former 85 pct; American Can Co. has dropped from 90 pct to 50 pct; American Smelting is down to 31 pct compared with 90 pct; and lastly, U. S. Steel which has plummeted from 65 pct to slightly more than 30 pct of the steel market. Declines of the same proportions have hit big companies in other industries. Price cuts on Detroit's 1953 automobiles indicate that even among the biggest competition is still one of the most important household gods. Big business is still slugging it out for the attention of the American consumer. It's a battle which can only have one result—benefit to the man who buys.

◆◆◆◆◆◆

AT various times the mining industry has been threatened with the activities of a variety of confidence men. Most of them have not been mining people, but rather a variety of confidence man, working various dodges from selling phony stock to enhancing the worth of a worked out mine for the benefit of widows and orphans.

Lately, there have been reports that a new type of confidence man has emerged upon the scene. This time, he is making the acquisition of public lands his prey. By filing phony prospecting claims, certain people have been able to take over valuable forest lands. Using the mining industry as a front, hundreds of claims have been filed in recreation areas. Perhaps a hole is dug to satisfy the requirements of the law. Claims are based on the assertion that minerals have been found. Often, the so-called prospector wouldn't know a mineral from a head of cabbage. The law requires that $100 worth of work be done annually. The claimant can keep the land indefinitely, and might take final title by doing $500 worth of *mineral development*, and getting a survey costing another $500. For an investment of $1100, he may acquire land worth perhaps $30,000. Hunting camps, summer homes, and other private recreation areas have been set up in this way, on 20 acres of public land.

Mining men have long been concerned with this situation. Recently, interest was noted in the American Farm Bureau Federation publication, *The Nation's Agriculture*. An article called *Land Grabbers In National Forests*, demanded action. The magazine may have erred somewhat however, in the statement that "mining group spokesmen maintain that present laws are stiff enough and that they can be used to end any abuses." Perhaps some mining men do feel that way. It is to be doubted, however, that the attitude is universal, as implied in the magazine.

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STEEL men will have many memories of 1952. Some memories, such as the steel strike, will be bitter, but others will stand as a symbol of the might of democracy and its economic system. Perhaps one of the most impressive events of the year took place at U. S. Steel's Homestead works in Pittsburgh, when the firm's billionth ton of steel was poured. No one can hope to measure the benefits that have come from this billion tons of steel. It has contributed to the happiness of many more Americans than can be counted. It has gone into refrigerators, automobiles, bridges, buildings, and countless other things we take for granted. And it has gone into the things that have made the nation safe, the tanks, guns, and ships which have been used to defend those truths we feel to be *self evident*.

Slightly more than 50 years were required to pour a billion tons, but Clifford F. Hood, new president of U. S. Steel, says that the next big development will be speeding the time required to convert iron and other raw materials into finished steel. At the rate U. S. Steel is currently operating, it could pour its second billion tons in 30 years. Today, this one company has roughly the same capacity as all of the Soviet Union.

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STEADY improvement in the copper supply situation has been counterbalanced to some extent by what appears to be a wave of scare buying. Copper users have been getting pelted steadily with talk of early copper decontrol. In most cases the talk has been without fact or foundation, perhaps coming as the result of some out-loud thinking by a few administration officials and industry executives.

Available copper has increased, but predictions that the situation would ease, made at the midpoint in 1952, have failed to be completely fulfilled. Certain controls in Europe and Britain have been relaxed, however, and it would appear that world supply has passed the danger point and is well on the road to good health. Mine expansion programs are starting to pay dividends, but use continues at a high level in the U. S. There has been a barely noticeable drop in European use of copper.

SAND casting of a magnesium alloy wing section by Aluminum Co. of America for Northrup Aircraft, Inc., created more than passing interest at the 8th annual meeting of the Magnesium Assn., Nov. 10 to 11, 1952, in New York City. The casting was made as part of a research project for the U. S. Air Force. The project was a segment of a long term program for casting and forging large aircraft components.

The wing section, 16 ft long, 3½ ft at its widest point, and with a minimum section thickness of ¼ in., was cast in two sections, using alloy AZ92-T6. Five hundred lb of magnesium was poured for the 200 lb wing. Alcoa's W. D. Stewart gave a limited account of the project, pointing out that security restrictions prevented him from giving a detailed description of casting practices.

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MODERN archaeological research and passages from the bible were pieced together and their juxtaposition gave rise to the discovery of King Solomon's copper mines in the Nahal Timba area of the Southern Negev in Israel. Archaeologists, delving into the biblical past, found remnants of smelting works. Soon after, the young nation discovered copper ore deposits which will be mined at a rate of 100,000 tons during the next seven months. Starting July of this year, production will be stepped up to half a million tons per year, according to Abraham Dor, chief engineer of Israel Mining Industries. Mr. Dor reports that a possible ore reserve of about 40 million tons is indicated by test borings. Probable reserves are estimated at 20 million tons.

During the next three years, mining will be by open pit, but preparations are being made to go underground. Israel faced a tremendous handicap in starting an underground program. The nation lacked the particular type of skilled labor required. For open-pit mining, the potash industry furnished the labor force.

But out of the bitterness of the past, four men were found with previous experience. They had been trained in the slave labor forces of Hitler. These men have served as the nucleus for training underground miners. Technical assistance from the U. S. Bureau of Mines, coupled with a program for sending Israel engineers to other countries for training, and plans to eventually found its own school of mines and metallurgy are expected to remedy the need for mining know-how.

Problems of transportation, water supply, and equipment are being solved, according to Dor. Other mining possibilities are indications of the existence of iron ore, phosphates, ball clay, and glass sand. Manganese exploitation at the King Solomon mine site is also being considered. Plans for treating 1½ to 2½ pct copper ore by chemical means, are being formulated.

REPORTS on free world tungsten steadily become more encouraging, as new discoveries are made and already operating mines expand production. Not so long ago the Chinese Communist Fourth Army marched into Kiangsi and Kwangtung Provinces, cutting off one third of world tungsten ore production. Before the Communist victory, tungsten ore sold at about $2000 per ton of 60 pct concentrate, compared with $6500 today. Exploration and development have been given a tremendous shot in the arm by the price. Free world tungsten production rose from 15,050 to 25,618 tons, in 1951. During the same period production in Communist controlled countries reportedly rose from 15,100 to 24,508 tons. Figures are for tons of concentrates, each containing 1049 lb of tungsten trioxide. U. S. output during the same period rose from 4403 tons to 5693 tons. Thus far, U. S. production has indicated that it will rise again in 1952. For the first half of the year, output reached 3,397,000 lb, compared with 5,869,000 lb for all of 1951.

South Korea has offered indications of growing importance in the world tungsten picture. Reserves have been reported at 2.28 million tons, with an average metal content of 1.7 pct. All South Korean tungsten concentrate is sent to the U. S., under an agreement between the two countries. Canada, never before significant in the tungsten scene, may prove to be another important factor in overcoming the handicap imposed by Communist China. Western Tungsten Copper Mines, Ltd., has announced that it plans to expand milling capacity at Red Nose mine on Rocher de Boule, near Hazelton, B. C., from 150 tons per day to 500 tons. Reserves of 500,000 tons have been disclosed with additional diamond drilling under way.

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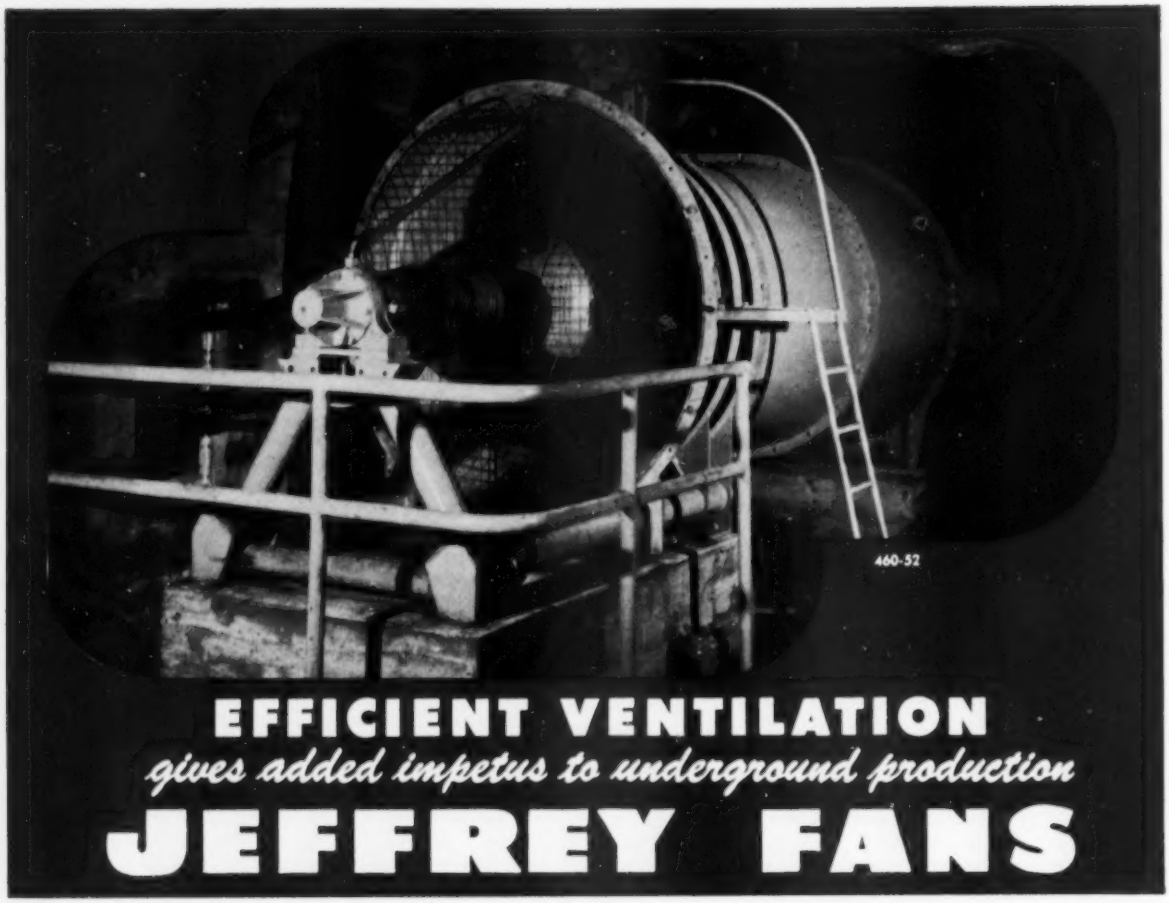
ONLY John L. Lewis is left. Philip Murray and William Green, who along with Lewis rose from the coal mines to take over the leadership of the American labor movement are gone. With them goes an era. Lewis remains, heading his powerful United Mine Workers. But men who concern themselves with past, present, and future of labor, feel that the new leader of the American Federation of Labor, George Meany, and Walter Reuther, president of the CIO, are totally different in philosophy.

Experts look forward to an era of true collective bargaining, unfettered by the fears and recriminations born and nurtured in the past of labor-management relations. It may be too early to tell. How much influence, Alan Hayward, lieutenant to Murray for many years, will have is unknown. Both the CIO and AFL heads are proponents of urbane conduct in the meeting rooms. Lewis is still available for fireworks and other labor pyrotechnics. Too often in the past, the conduct of the UMW has had far reaching effects over the entire industrial front of the nation.



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Illustrated is a 12 A 58 Aerodyne Fan installation at the U. S. Potash Co., Carlsbad, N. M. This is only one of many similar installations in the metal and non-metallic mining field. This model fan is designed for 13" W.G. maximum pressure and volumes up to 600,000 c.f.m. It features internal self-circulating oil lubrication and separate ball thrust bearing. All fan installations are engineered to meet operating requirements.

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Drift of Things

IKE'S amiable expression and apparent sincerity impressed AIME members as did the theme of his talk. Cautioning against the gradually increasing power of the federal government, he said: . . . "freedom as we know it is in no greater danger from without than it is from our own lack of understanding of this creeping paralysis from within." Next February, it will be three years since he uttered these words at Annual Meeting welcoming ceremonies, but the theme was oft repeated in his winning campaign. This brush with the exalted, brief though it was, makes Washington look friendlier to many AIME members than it has for years.

In addition, and probably more important to AIME, is appointment of George M. Humphrey, member since '22, as Secretary of the Treasury. Born and raised in Michigan, Mr. Humphrey went on to Ann Arbor to study law. Three years after joining the M. A. Hanna Co., and when only thirty, he became a partner. Today he is chairman of the board but the record of his other accomplishments such as the organization of National Steel Corp. in 1929 and Pittsburgh Consolidation Coal Co. in 1945 indicates that he has blended law books with balance statements well. Younger blood remembers his name most in connection with the Labrador-Quebec iron ore deposits. Mr. Humphrey helped form the Iron Ore Co. of Canada, and became its first president. Labrador-Quebec is taken quite for granted today as one of the promising new sources of ore, however, it did not get that way without a great deal of selling. Mr. Humphrey and others had to have the courage to back up a difficult, but good, engineering bet.

FROM the business man's viewpoint, it was reported at the annual meeting of NAM, the election resulted in a new and hopeful opportunity to show what business really looks like when not villainized by hostile government. And the President-elect has given business a square shake in his selection of advisers. Now that the public is getting another chance to see what free enterprise can do, business must put its best foot forward.

An honorable end of the Korean war is naturally the most-to-be-hoped-for achievement of the administration. We concur, but there are some things which we hope will be given high priority on the new administration's list of things to be done. Business has long claimed that redistribution of the tax load can be done in a way to encourage business growth and the presumption is that more business means more sources of tax revenue. Secretary Snyder was always willing to listen to such proposals but usually dampened enthusiasm for studies of tax reform when he said in effect: any tax reforms will be considered so long as they produce the same revenue. Mr. Humphrey will have a tough time with this one particularly since a large percentage of the short term debt will become due in the next four years and defense expenditures will be difficult to cut.

Then there is the State Dept. Conversation of mining men overheard in a Lima, Peru, hotel lobby led us to believe that the prestige of the U. S. in the Western Hemisphere has dwindled to a very low ebb indeed. Apparently a mine manager representing a U. S. firm in Bolivia had been incarcerated on trumped-up political charges by the local government. The man happened to be a British subject and his government had him released in short order. Consensus among U. S. citizens: that he was fortunate to be British not Yankee (or he would still be in jail). Apparently being a citizen of the U. S. no longer carries the prestige and security abroad which it did. In this era, when the role of the U. S. in world affairs is in the ascendency, it is more important than ever that our citizens abroad be protected.

Investigation of business by government could be a little more responsible. For instance, Mr. Hoover of the FBI conducts his business in a quiet, thorough, and nonpolitical manner. There have been cases where the Government used notoriety and flamboyance in its prosecution of corporations—to make political hay regardless of verdict.

WE had a tough time getting wrappers big enough to carry this three-section mailing of the journals. All AIME members should have received a magazine, the index of the 1952 Journal, and a copy of the *Yearbook and Directory*. Directories were not sent to students or nonmember subscribers. In thumbing through the Yearbook section, we were impressed by the tremendous compilation of historical and current data on AIME which was provided by the Secretary's office. Certainly a great number of people are taking and have taken active parts in the affairs of the Institute.

The listing of members in the Directory section is both alphabetical and geographical. In 1950 an experiment with a geographical-company listing of members was undertaken in the Directory of that year, but the Council of Section Delegates reported it to be confusing and of less value than the straight geographical listing.

A new method of keeping the Directory data has been used. It is called Flexoprint and was developed by Remington Rand. Names, titles, and addresses as they appear in the Directory have been typed by electric typewriter on cards which are inserted in frames. Each frame represents a page. The frames are photographed and printing plates made from the negative. As changes of position or company listing are received at headquarters, they will be immediately typed on cards and inserted in their proper position in the frames. When a new Directory is wanted, it is only necessary to make the printing plates by photo-offset. No special preparation is required or proofreading. The entire process, including amortization of investment for the system, will lower the cost of Directories.

Following the names listed in the geographical section are code letters. Once you become familiar with them (and it takes some doing) they are quite useful. They indicate which of the ten Divisions of AIME a member belongs to. You are entitled to belong to as many as you wish, hence the multiplicity of letters after each name. For the key to the code turn to page 233 of the Directory. The system reminds us of the remark made by a perplexed student of descriptive geometry: "It's not the intrinsic difficulty of the problem which bothers me, it's multiplicity of detail."

FOR about four years we have been carrying on a continuous readership study of the magazine and the editors have long been impressed by the fact that the "Drift of Things" as followed by E. H. Robie has consistently ranked high in readership among the features. Further evidence of the excellence of the product of his portable typewriter is manifested by the thick folder of correspondence in our files marked "Comments on Drift." The growth of the Institute in recent years both in membership and activities has multiplied Mr. Robie's work to the point that he has decided he can no longer continue "Drift." We will try, however, to persuade him to step in as a guest writer at every opportunity.

John V. Beall

(LEFT)—Portal of Storke level haulageway that goes 3200 ft into mountain to orebody and development workings. Twenty-car trains will bring ore to the surface and the crushing plant through this 9x14-ft opening. View from Position No. 1 bottom page 37. (RIGHT)—Housing a 60-in. Nordberg gyratory and two 7-ft Symons cone crushers, plant shown will reduce large run-of-the-mine ore to a 1½-in. product for transportation to fine ore bin. Ore trains will enter building through large opening on the left and dump directly into the gyratory. View from Position No. 2.

Storke Level: Key to $25 Million Climax Project

In these troubled times free enterprise is maintaining vital molybdenum output, while expanding plant, and bringing in new low grade ore reserves, at Climax, the world's largest known molybdenum deposit. Climax Molybdenum Co. is putting $25 million into additional surface plant facilities and other millions into underground development. The expansion program to be operating by 1954 includes a new mining level, crushing plant, 4000-ft conveyor, milling units, by-products plant, and housing for 198 families. Completion of this program and low grade plant will add 10,000 tons per day to present capacity and several million tons to ore reserves.

by Charles M. Cooley, Associate Editor

Why Climax Chose New Adit and Conveyor for Storke Level Expansion

Problems arose in the expansion program, stemming from early days of the operation when original planning for the mine, crushing and milling plants, and townsite was based upon the assumption that Phillipson level was the economic bottom of the ore. Since then the theory has been proved false.

Existing plant was too large to consider relocation at a lower elevation. Access, transportation, and ore handling from the new level, 300 ft below Phillipson workings, was the important problem. Any transportation plan had to take into consideration that ore as mined was too large for standard handling methods, other than large ore cars. It would necessitate crushing before transfer.

Skip hoisting or belt conveyor would require a large underground crushing installation which would be difficult because of the unusually heavy and unpredictable rock pressures encountered in caving operations.

Another scheme involved haulage up a long adit, on 6 pct grade, direct to present crusher bins. It was discarded because of the length of haul, heavy locomotive equipment required, and the cost of some 500 ft of large tunnel. A marshalling yard would have been needed underground to make up longer trains for the trip to the surface and to remake the 20-car ore trains upon return.

The plan finally chosen takes advantage of terrain, with an adit driven to the orebody from the east side of the Continental Divide. It provides haulage on favorable grade, permits a surface location for crushing plant, and ties into the existing plant with a conveyor belt system.

(LEFT)—Stabilizing the slope to provide steady foundations for the 42-in. conveyor belt proved to be a major problem in the construction of the 4000-ft transportation system. Cribbing in the photo outlines the conveyor path from the lower right corner to the extreme left where the belt crosses the Continental Divide at an elevation of 11,325 ft. Viewed from Position No. 3. (RIGHT)—New milling unit that will add 5000 tons per day to the present mill capacity. West extension of new mill, not yet erected, will increase tonnage by an equal amount. Inclined conveyor (partially covered) brings ⅜-in. material from the 7-ft short head cone crushers in No. 2 crusher station. Viewed from Position No. 4.

RECOGNIZING the strategic importance of an ore deposit yielding 46 pct of world molybdenum output, and more than one million lb annually of tungsten concentrates (60 pct WO_3), Climax Molybdenum Co. has launched a $25 million expansion at its Climax mine, underway 100 miles west of Denver, atop Fremont Pass and the Continental Divide.

Planned for completion by 1954, the program calls for a new and lower mining level, greater mill capacity, together with transportation, water supply, and housing facilities to support this expansion.

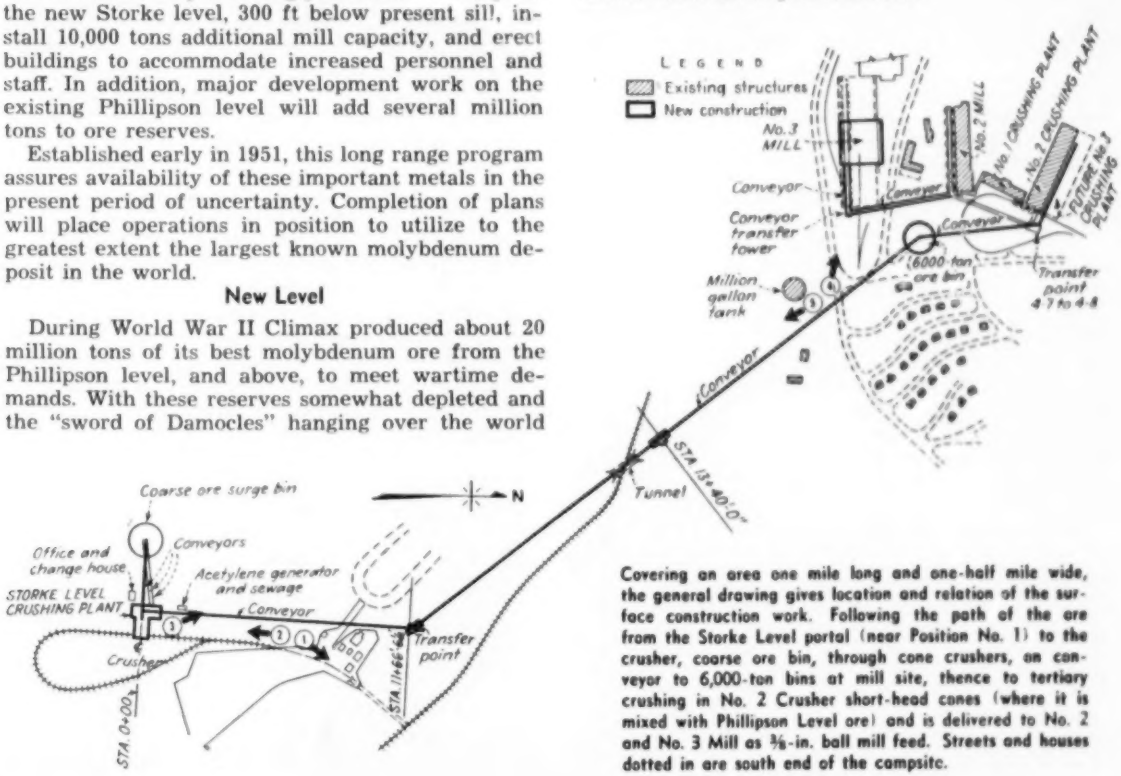
Construction is proceeding year round to complete the new Storke level, 300 ft below present sill, install 10,000 tons additional mill capacity, and erect buildings to accommodate increased personnel and staff. In addition, major development work on the existing Phillipson level will add several million tons to ore reserves.

Established early in 1951, this long range program assures availability of these important metals in the present period of uncertainty. Completion of plans will place operations in position to utilize to the greatest extent the largest known molybdenum deposit in the world.

New Level

During World War II Climax produced about 20 million tons of its best molybdenum ore from the Phillipson level, and above, to meet wartime demands. With these reserves somewhat depleted and the "sword of Damocles" hanging over the world today, plans were formulated to make another portion of the orebody, along with sufficient milling capacity, available on short notice.

Development of new level makes use of abrupt drop in elevation to the south of the plant and on the east side of the Continental Divide, where an adit could be driven into the mountain to meet the orebody. By taking advantage of terrain, ore mined on the Storke level could be hauled 4000 ft on favorable grade to a surface crushing plant and then transported by conveyor belt to present facilities. The basic plant will eventually make available 100 million tons of molybdenum ore.



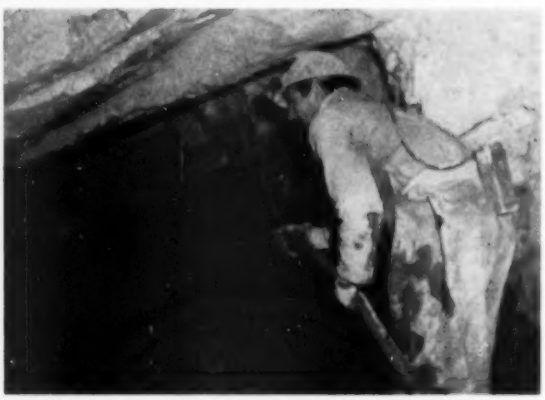
Covering an area one mile long and one-half mile wide, the general drawing gives location and relation of the surface construction work. Following the path of the ore from the Storke Level portal (near Position No. 1) to the crusher, coarse ore bin, through cone crushers, on conveyor to 6,000-ton bins at mill site, thence to tertiary crushing in No. 2 Crusher short-head cones (where it is mixed with Phillipson Level ore) and is delivered to No. 2 and No. 3 Mill as ⅜-in. ball mill feed. Streets and houses dotted in are south end of the campsite.

Placing 240 cu yd Concrete per Day

1 Starting its trip underground is the specially built 24-batch mine car. Equipped with self-unloading conveyor belt, the car supplies the underground concrete plant with measured quantities of cement, sand, and gravel.

3 Removable steel forms used to concrete slusher drifts, giving lower forming costs in both material and labor. Forms go up rapidly and accurately for minimum down time of the Pumpcrete plant and operating crew.

2 Business end of underground concrete plant which consists of a 34-cu ft Ransome mixer, 3-cu yd Rex remixer, and 200L Single Rex Pumpcrete machine. Up to 240 cu yds per day can be placed with this apparatus. Each 100-ft slusher drift requires about 800 cu yd of concrete for operation.



4 Adjoining picture shows pipe going into top of form and here miner is shown working with air-operated vibrator, the fresh concrete being pumped in through the pipe. This reduces entrapped air and resulting weakening of concrete.

Progress Proceeds Apace

Since the inception of the program, great strides have been made. The contract for the first phase of Storke Level development has progressed beyond the half-way mark. Ten thousand ft of haulage drifts have been completed in the portion under development; 8000 ft of ventilation drift, 5000 ft of slusher drift, 18,000 ft of undercutting, longholeing for removing pillars in 23 stopes, and 20,000 cu yds of underground concreting have also been finished. This work has been accomplished by a crew of 300 men in one and one-half years.

The mining contract has progressed well ahead of schedule in spite of pioneering this type of agreement. Not only did the job include tunneling, but the undercutting for caving and the mine preparation work. Conditions growing out of sudden expansion, such as lack of housing and trained personnel, made it necessary to place the development work in the hands of an outside organization.

Gibbons & Reed, Inc., have carried the program through to its present status with only a few minor delays and mishaps.

Successful handling of the mine development is pointed up by these progress rates:

1—9x12½ ft slusher drifts. Advance per machine drill shift, 10 ft.

2—8x9 ft undercut at 45°. Advance per machine drill shift, 9 ft.

3—Longholing of undercut pillars. Drilled per machine drill shift, 180 ft.

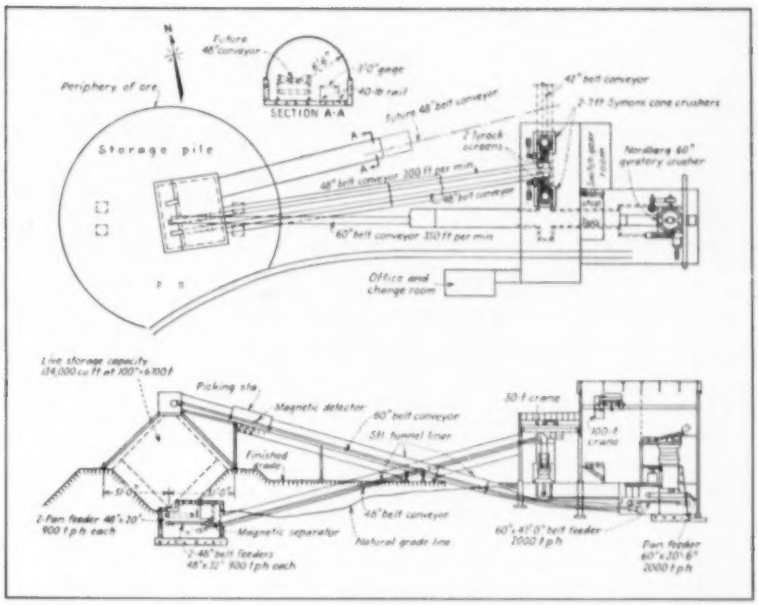
4—Concrete in slusher drifts. Maximum daily pour, 240 cu yds.

Liberal employment of bonus payment has been given much credit for this high progress rate.

Crusher Near Completion

The new crushing unit, located about 900 ft from the Storke Level portal is approaching completion with the installation of a 60-in. Nordberg gyratory crusher, one of the largest in operation. The 9-in. product from this giant machine will be further reduced to 1½ in. in two 7-ft standard Symons cone crushers before dropping on the 42-in. conveyor.

The structure housing the crusher is complete. The building will be heated throughout and is a



Many new features are incorporated in the new Storke level crusher, including earth coarse-ore bin and conveyor belts enclosed with semicircular corrugated-tunnel support. Covered belts will also be heated to maintain temperature above freezing.

structural steel frame with siding made up of two sheets of corrugated galvanized iron with insulation sandwiched in.

An interesting feature in the new crusher plant is the construction of the coarse ore bin. Main confining portion of the bin is an earth fill, sloping 1:1 into the concrete bottom, accommodating feeders for conveyors carrying ore to the Symons cone breakers. The circular earth structure is covered with an inverted cone of steel and corrugated iron. The vertex of the cone is at the discharge of the 60-in. belt from the gyratory. This type of bin is feasible at Climax because of low ore grade and quantities handled. Some of the boulders in the construction area actually contain molybdenite.

The 4000-ft long 42-in. conveyor to transport ore from the Storke crusher to the storage bin at the mill is near completion. Not only will the belt move the 1½-in. ore three-quarters of a mile, but it will rise 300 ft.

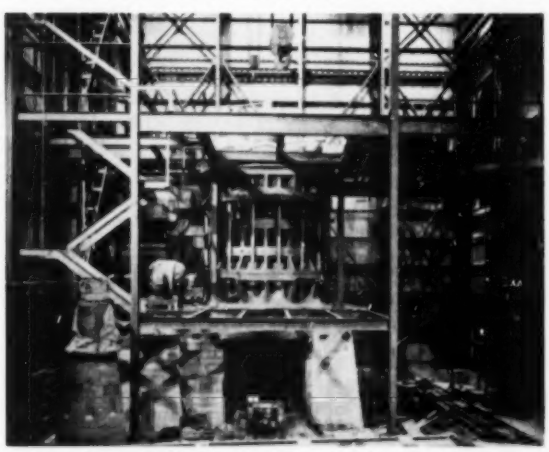
The ore, upon reaching the present mill area, will be introduced into the circuit at the No. 2 crusher where 7-ft short-head Symons will reduce it to ⅜ in. for ball mill feed.

An intermediate storage bin will take up any irregularities between the Storke and the No. 2 crusher. The 6000-ton bin will feature the same type of construction as the Storke Level coarse ore bin.

Conveyor belt and related equipment are not unusual, but novel housing is used. Standard corrugated semi-circular tunnel lining will cover the entire length of this belt as well as all other belts outside main structures. This eliminates the customary superstructure for the enclosure. Flooring of the conveyor structures is vermiculite concrete placed on a relatively light steel floor. This concrete is lightweight and has insulating properties. The 42-in. conveyor housing has electric convection type unit heaters for its entire length. Temperature inside the conveyor galleries will be kept above 35°F at all times.

Mill Units Ready to Roll

Completion of the present installation will boost Climax milling capacity to 20,000 tons per day. The



Giant 60-in. Nordberg gyratory, world's largest, will reduce 5 to 8-ton pieces of ore to 9-in. material. At a level 37-ft above the floor, 10-ton Granby type cars will dump directly into the one million-lb machine.

Looking down 42-in. conveyor line toward the Storke Level plant. Buildings to left are near portal and crusher is on the right. Platform supporting conveyor will be filled with vermiculite concrete and covered with corrugated tunnel support. Viewed from Position No. 5, sketch on page 37.

insulated steel buildings house 9x9-ft Marcy mills, 78-in. Akins duplex classifiers and 108 flotation cells of three different makes to provide three rougher grinding-flotation circuits. Mechanical handling apparatus in the new mill is designed for maximum efficiency with minimum operator fatigue. An elaborate monorail hoist setup is located in the flotation section for moving medium weight objects. Instrumentation has been freely incorporated into the milling procedure.

Plans are to add three more milling units to this plant in the near future to process low grade ores from the Phillipson Level. Low grade material will be milled separately. A plan has been established with the Government to mine the otherwise uneconomical ores. Additional funds will be spent for the construction of these milling units and other required facilities. Mill capacity will be 25,000 tons per day when completed in 1954.

Increase Phillipson Production

Existing reserves assume great importance in light of pressure to produce molybdenum. Rapid clean-up of good grade ore lying on cone shaped footwall area above the Phillipson workings is necessary to keep plans for the new Storke level, which will cave out workings above, on schedule. Approximately $4 million will be spent in preparing footwall ore for extraction.

Other Facilities Grow

Additional milling capacity puts pressure on water supplies and pumping equipment. The main storage area for mill water is Robinson Lake. This man-made area to impound run-off water is located 4½ miles from camp and about 400 ft lower. To assure a sufficient water supply, a 26-in. steel pipe line was constructed to supplement parallel to an existing 20-in. line now in use.

Expansion also outgrew available domestic water storage. By cleaning out undergrowth in the valley above Robinson Lake and constructing an earth dam, a pipeline, and a pumping station, an abundant supply of clear, clean mountain water will be available to camp residents.

Growing pains bring about increased needs in almost every phase of the plant and living facilities. The general office has added extensions to take care of increased personnel in the accounting, geologic, and engineering departments.

New construction has necessitated moving older buildings. The garage and transportation department has been relocated, utilizing a portion of the flat area afforded by the abandoned tailings pond.

Housing is Vital

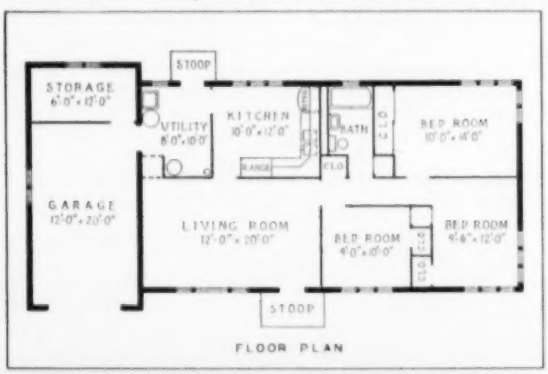
Following the thinking that comfortable housing is required for satisfactory operation of any mining camp, Climax, in addition to its 256 existing housing units constructed 50 six-room units with garage facilities. Scattered about the camp, the low, brightly colored structures make the alpine-like village more attractive.

The houses are of a precut type utilizing a relatively new product, Cemesto paneling as the exterior walls. The 4x8-ft panels of the laminated material are set in a wood framework forming a tight, warm structure, with exterior only 1 11/16 in. thick. Laminated Transite and sugarcane pulp panels make up the interior partitions. Heating is provided by three butane furnaces supplying 105,000 Btu. Long, cold winters make good heating the key to comfort.

The floor plan shows the very compact, well designed houses which add to the comfort and permanence of the operating crew.

However, individual houses are costly, heating inefficient, service difficult, and maintenance high. Confronted by greater housing requirements, Climax decided on multiple-unit housing to alleviate the shortage. Three 18-unit frame structures 30 ft wide and 190 ft long were constructed on the hillside overlooking the campsite. Eight additional buildings with 144 units will be constructed during 1953.

The buildings have six apartments on each floor with individual entrances, both front and back. Intermountains Builders, Inc. are erecting units at a fast pace and all will be ready for occupancy in the near future.



FLOOR PLAN

LEFT—Floor plan of new precut houses exhibits design for comfort and good-living in mine camp accommodations. LEFT, BELOW—Photo shows the pleasing lines of the buildings. BELOW—Shown still under construction, three buildings of the 18-unit apartment type.

Climax By-product Plant Operating at Full Capacity

Construction of additional plant capacity for processing the tailing from the molybdenum rougher mill started in the spring of 1951 and the plant began operation in early 1952. Tungsten, tin, and pyrite production, from a mill product discarded prior to 1948, has become an important portion of the milling program. The original installation, constructed in 1948, was designed to process 7000 tons of tailing. Successful operation of the first by-products plant made expansion to 20,000 tons per day desirable.

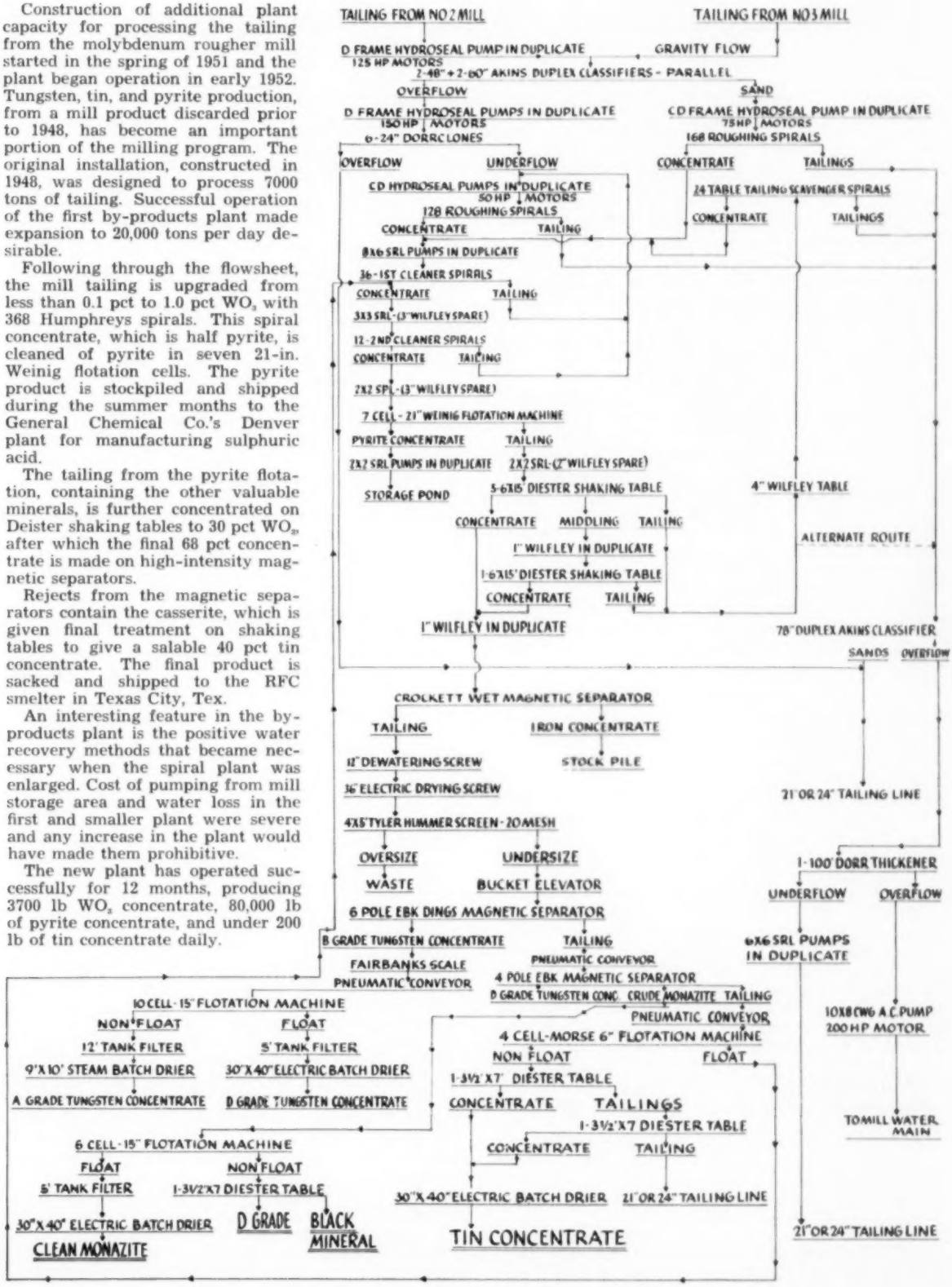
Following through the flowsheet, the mill tailing is upgraded from less than 0.1 pct to 1.0 pct WO_3 with 368 Humphreys spirals. This spiral concentrate, which is half pyrite, is cleaned of pyrite in seven 21-in. Weinig flotation cells. The pyrite product is stockpiled and shipped during the summer months to the General Chemical Co.'s Denver plant for manufacturing sulphuric acid.

The tailing from the pyrite flotation, containing the other valuable minerals, is further concentrated on Deister shaking tables to 30 pct WO_3, after which the final 68 pct concentrate is made on high-intensity magnetic separators.

Rejects from the magnetic separators contain the casserite, which is given final treatment on shaking tables to give a salable 40 pct tin concentrate. The final product is sacked and shipped to the RFC smelter in Texas City, Tex.

An interesting feature in the by-products plant is the positive water recovery methods that became necessary when the spiral plant was enlarged. Cost of pumping from mill storage area and water loss in the first and smaller plant were severe and any increase in the plant would have made them prohibitive.

The new plant has operated successfully for 12 months, producing 3700 lb WO_3 concentrate, 80,000 lb of pyrite concentrate, and under 200 lb of tin concentrate daily.



Germanium —

Byproduct of Primary Importance

Most of the production of germanium in the U. S. is from byproducts of smelting Tri-State zinc ore. Only in England has commercial manufacture been reported from coal.

GERMANIUM, studied for years from a chemical standpoint, had to await the advance of science before it could be put to work for the benefit of humanity. Although small quantities of germanium and many of its compounds were prepared and several uses suggested for them, it was not until the fundamentals of solid state physics were developed that much attention was paid to germanium.

It is increasingly true that scientists use a *library* approach in their search for certain properties. They list the properties desired for a certain material and then inspect the entire field for such a material. In the course of developing crystal rectifiers during World War II, the National Defense Research Council wanted a material or materials with semiconducting properties that could be made of high purity and handled easily. Of the materials selected, pure germanium proved one of the most adaptable and the commercial manufacture and use of germanium really dates from this work. The rapidly advancing achievements in the field of semiconductors and their utilization in numerous applications have made germanium an important element, although production is small compared to many elements.

Early History

Many years before the advent of solid state physics, university workers investigated germanium and its compounds, but the metal was only a scientific curiosity. As is often the case with such rare elements, it sold for $10 per g. The presence of germanium in Tri-State (Missouri-Oklahoma-Kansas) ores was known prior to 1920; Waring publicly identified it, although other scientists in that area also studied its occurrence there. In 1935, McCutcheon showed that germanium was concentrated in certain byproducts of the zinc smelting operation at the Eagle-Picher plant in Henryetta, Okla. and, after considerable study, was successful in further concentrating the germanium. Additional studies, both at Henryetta and in the Eagle-Picher research laboratories in Joplin, Mo., resulted in pilot plant scale production of germanium dioxide about 1941. At that time, no commercial uses were known.

About 1942, the National Defense Research Council began work on germanium. The pilot plant was then producing GeO_2 of 99.9 pct purity which, although good, was not pure enough for rectifier purposes. Continuous cooperation between producer and consumers improved the purity until today the total impurities are only a few parts per million, while the electronically important impurities are normally in fractions of parts per million.

This material has been abstracted and extracted from an article, by A. P. Thompson and J. R. Musgrave, published in *Journal of Metals*.

Occurrence

Germanium occurs in the earth's crust in the same order as zinc and lead. It has been estimated that 4 to 7 g of germanium are present in each ton of lithosphere. However, unlike zinc and lead, there is very little concentration of germanium which allows economic exploitation. No minerals are known in which germanium is the primary constituent, although in germanite and renierite it is a secondary metal. Some germanite has been found in the copper-lead mines at Tsumeb, South West Africa; the run-of-mine ore assays 3 to 4 pct Ge. The occurrence of germanite is reported to be erratic, but such ore as is available is used as a raw material for germanium recovery. Renierite, found in the Belgian Congo, is reported to be available in sufficient quantity to make it commercially attractive.

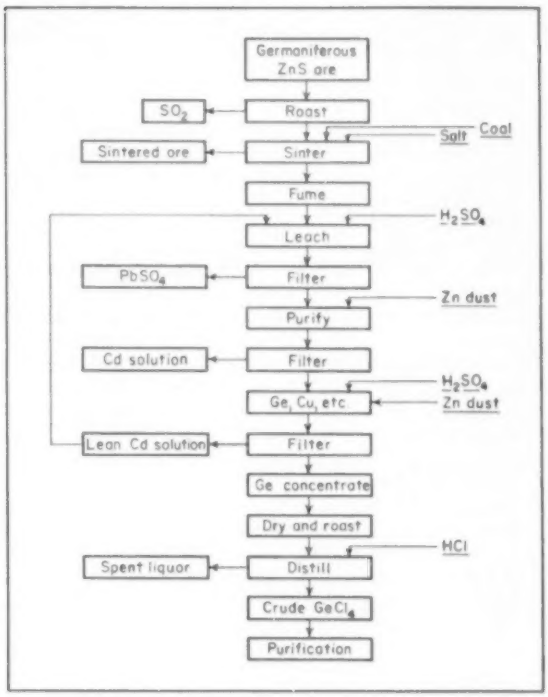
Some silver, tin, copper, zinc, and iron ores contain small amounts of germanium, 0.01 to 0.1 pct. These traces cannot be economically recovered from the ore, but in some cases germanium can be recovered as a byproduct during the recovery of the primary metals. Most of the U. S. production of germanium is from byproducts of zinc smelting (from Tri-State ore). Germanium is found in coals from many parts of the world. Under proper conditions of combustion, germanium is retained in the ashes or other byproducts of the burning. Exploitation of this source is dependent on sufficient amounts of germanium in these byproducts to allow economic recovery. Only in England has commercial manufacture of germanium been reported from this source. Some American coals have been investigated for germanium but no utilization of coal byproducts in the U. S. has been reported.

Recovery from Ore

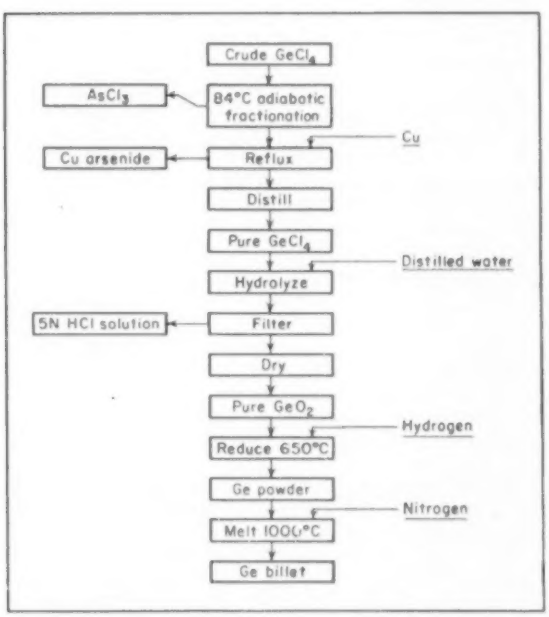
Each raw material for germanium recovery poses its own set of problems in extractive metallurgy. Flow sheets for producing germanium tetrachloride from the three present sources—zinc ore, germanite, and coal—are given on page 43. A flow sheet for the translation of the crude tetrachloride to purified metal is also presented.

In the recovery from zinc sulphide ores, the zinc sulphide containing 0.01 to 0.015 pct Ge is first roasted. The roasted ore is mixed with coal and salt and sintered at a high temperature. Germanium, cadmium, lead, and some other metallic impurities are volatilized and the vapors condensed and collected in an electrostatic precipitator. This fume is reacted with sulphuric acid and the lead precipitated as lead sulphate. Zinc dust is then added in sufficient amounts to precipitate the copper and germanium without throwing down the cadmium. Some arsenic

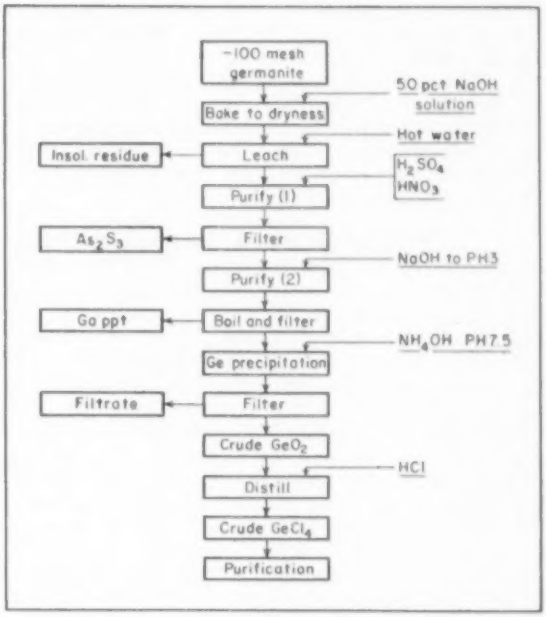
Flow Sheets of Processes Producing Germanium from Tri-State Ore, Germanite and Coal



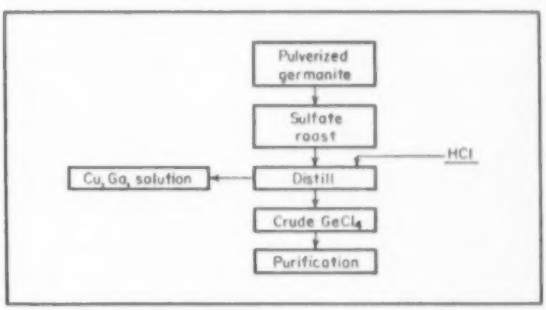
U. S. PRACTICE—Most of the production of germanium in the U. S. is from byproducts of smelting Tri-State zinc ores. This flow sheet illustrates general practice for these ores. The germanium tetrachloride end product of this flow sheet is purified by the general treatment shown below.



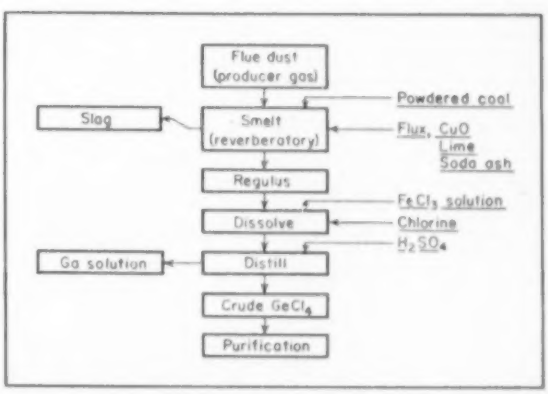
PURIFICATION—Germanium tetrachloride is purified in this British process, hydrolized to germanium dioxide, and the dioxide reduced. The American process for purifying the tetrachloride differs only slightly in that adiabatic columns are not used, and the copper refluxing step is omitted from the procedure.



BRITISH GERMANITE PROCESS—This British germanite practice is somewhat more complicated than the U. S. process utilizing the same ore.



U. S. GERMANITE PROCESS—Some germanium is recovered commercially from Germanite in this U. S. process, it differs somewhat from the British practice shown above.



COAL PROCESS—Only in England has commercial success been reported on the production of germanium from flue dust. American coals are being investigated for germanium.

and other metals are also precipitated at this stage. The copper-germanium precipitate is filtered off and the solution is sent to the cadmium recovery unit. The germanium-bearing sludge is redissolved and the germanium concentrated by a second precipitation. This germanium concentrate is then roasted and the roasted concentrate dissolved in strong hydrochloric acid. Germanium tetrachloride, along with some hydrochloric acid and arsenic chloride, is distilled from this solution. This is the crude tetrachloride charged for purification.

Recovery from Coal

Large quantities of British coals are used to make coke for producer gas plants. In the combustion of producer gas, germanium is largely volatilized. Upon cooling of the combustion gases, much of the germanium, and some other metallic constituents, are deposited as a dust in the flues. This flue dust is smelted with soda ash, lime, copper oxide, and coal dust (iron is also desirable, but is usually present in sufficient quantity in the dust) to form a regulus and a slag. Under proper smelting conditions, the regulus will contain most of the germanium and the gallium. The regulus is then treated with a current of chlorine under a dilute solution of ferric chloride, the gallium and germanium being converted to soluble chlorides. The germanium tetrachloride so formed is distilled off and collected, along with some arsenic chloride. This crude tetrachloride is then further purified.

Recovery from Germanite

Germanium has been recovered commercially from germanite in both England and the U. S. The processes differ somewhat. In the British method the pulverized germanite ore is reacted with 50 pct sodium hydroxide solution and the mixture evaporated to dryness. The dry mass is leached with hot water and the leach solution brought to pH 8 with sulphuric acid. Under controlled conditions, nitric acid is added to the boiling solution to give 5 pct of free acid in the solution; after filtering, this solution is brought to pH 3 with sodium hydroxide to precipitate the gallium. The gallium precipitate is filtered off and the germanium precipitated (as dioxide) by neutralization with ammonia. The germanium dioxide is then filtered from the solution, dissolved in strong hydrochloric acid and the resultant crude germanium tetrachloride distilled. In the American process, however, the ore is pulverized and then roasted under controlled conditions, after which it is reacted directly with hydrochloric acid. Germanium tetrachloride is distilled from this hydrochloric acid solution and the crude tetrachloride sent to the purification process.

Purification

In the purification of the crude tetrachloride, the American method employs multiple distillation of the crude germanium tetrachloride, either as a batch or column process, with the final distillations being conducted in the presence of chlorine and hydrochloric acid. The British process is much similar, except that adiabatic columns are used and an additional step of refluxing with copper is employed to eliminate arsenic. The pure germanium tetrachloride from either process is hydrolyzed in distilled water to germanium dioxide, which is then washed and dried. Scrupulous cleanliness is essential at all stages to insure no contamination of the final product. The germanium dioxide is reduced to a powdered metal by heating to 650°C in an atmosphere of hydrogen. The powdered metal is melted at 1100°C in an inert atmosphere to form billets.

For electronic uses, germanium metal is further purified by fractional recrystallization. The metal, contained in a graphite boat, is melted in a horizontal tube furnace at 1000°C, either in an inert atmosphere or under vacuum. Upon slowly cooling the molten metal from one end to the other, the impurities concentrate at the two ends of the ingot, leaving the center section relatively pure. Additional recrystallizations of the center sections may be necessary to achieve the desired purity.

Commercial production of germanium dioxide was begun about 1941 by the Eagle-Picher Co. Demand was limited until the development of the germanium diode for use as a crystal rectifier. By 1948, the production of germanium dioxide had reached 1000 lb per year in the U. S. Since that time, demand has increased until, in 1951, it was estimated that 5000 to 6000 lb were produced. The Eagle-Picher Co. is the dominant producer, recovering it from zinc ore. In 1950, Johnson, Matthey & Co. began production in England from flue dusts (coal). Some germanium is produced on the continent, but no data are available on quantities from either Europe or England. The price of germanium metal in the U. S. is currently $340 per lb; the dioxide sells for $142 per lb. Small quantities are somewhat higher.

Uses

The high cost of germanium is no deterrent to its use in most electronic devices, since the quantity necessary is quite small. For example, a germanium diode, which currently sells for about $1.25, contains only a few cents worth of germanium. Proper preparation of the metal and the fabrication of the devices constitute a major portion of the cost.

The first type of germanium devices to achieve commercial importance was the germanium diode, which is essentially a fine wire of appropriate metal pressing against a thin wafer of properly prepared germanium. Both wire and wafer are soldered to electric conductors and a suitable covering provided. The complete assembly is only the size of a grain of corn. The two-element unit acts as a crystal rectifier and, within the limitations of the unit, will perform the same functions as a vacuum tube diode. Besides its advantage in size, it is far more rugged and consumes only a very small amount of power (and gives off very little heat) compared to the vacuum tube. In addition, it begins functioning at once, while the vacuum tube must await heating of the filament. Because of these advantages, it is possible to use germanium diodes in many places to replace vacuum tubes, giving more compact and serviceable units. These germanium diodes are being produced at an estimated rate of seven to eight million per year.

Germanium triodes, known as transistors, were invented by Bardeen and Brattian of the Bell Telephone Laboratories in 1948.

The photoelectric effect of germanium diodes, first observed during the development of crystal rectifiers, has been carried to commercial utilization in photoelectric devices. They are said to have definite advantages over the present *electric eyes*.

Germanium rectifiers that will operate in the ranges of selenium and copper oxide rectifiers are in the development stage. Some magnesium germanate is used as a phosphor in fluorescent lamps.

Resurrection Cuts Mining Costs — Makes Lower Grade Ore Economic

Square-sets go out and labor saving combination of top-slicing and sub-level caving raises tons per man hour 300 pct, cuts timber cost 50 pct to permit mining lower grade ores.

by C. N. Stout and John S. Wright

MINING operations at Resurrection Mining Co.'s No. 2 shaft, near Leadville, Colo., reached the stage where continued operation in the face of rising costs had become critical. If the mine was to continue working on marginal or low-grade lead and zinc ores, timber and mining costs would have to be cut, and tons per man-shift would have to increase. Answers were found to these problems on the iron ranges of Northern Minnesota at Oliver Iron Mining Co. and Pickands-Mather Co. mines at Ely, Minn.

In 1950 the Resurrection management investigated top-slicing and sub-level caving used in the mines and decided that a combination of these methods would do the job for Resurrection in the Fortune vein.

It is not intended to portray sub-level caving or top-slicing methods but to show where modification of these mining methods can be applied to areas presently being square-setted. It is the authors' opinion that nearly any ground being square-setted can be mined cheaper, safer and with less skilled labor under this system.

Strongest indication of success for the new approach is comparison of cost of square-set stoping used at Resurrection for years, with that of the modified top-slice sub-level method adopted. Taking the first seven months of 1952 as typical of the new system and of 1947 through 1950 as a base period for the old method, results show a 40 pct saving on direct labor cost, 54 pct on timber cost, 25 pct on powder, and 43 pct for total direct mining costs.

Saving on labor cost contrasts sharply with a wage rise of 72 pct to employees on bonus payment. But because tons per man-shift increased from 5.19 to 15.93, cost per ton of ore mined has decreased. Approximately 350 tons per day are produced from the six stopes employing this method, using about one-third the crew for the old square-set method.

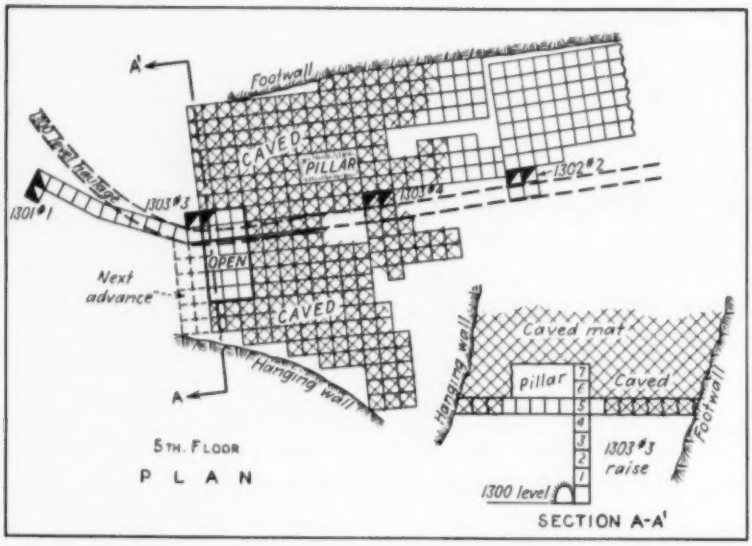
C. N. STOUT is general foreman and JOHN S. WRIGHT is mine superintendent, Resurrection Mining Co., Leadville, Colo.

New Mining Method Adopted

In brief, the method adopted for mining the 1300 Level of the Fortune vein is principally a sub-level caving method. Two-compartment raises were driven from the 1300 Level to connect with the previously mined 1200 Level on 100-ft centers. Tops of the service raises are connected by drifts for ventilation and slushing on the top floor. After driving connections between the raises, mining consisted essentially of retreating down the raise with sub-levels established at 19 ft intervals and driven along the strike of the vein. Practice varies with the width of the ore encountered but usually at the next raise a slice crosscut is driven perpendicular to the sub-level drift from hanging wall to footwall. After the crosscut is completed, caving of the 8 to 10-ft pillar between the floor of the sub-level above and the back of the crosscut is started, retreating toward the sub-level drift. This procedure is continued, retreating toward the manway and ore pass raise, taking out a slot approximately 100 ft long, the width of the ore body and some 20 ft thick, and allowing the mat from the floor above to drop down.

Disadvantage of Old Methods

Prior to 1950 the major portion of the ore produced from the Fortune orebody was extracted by a square-set vertical slicing system which involved driving waste raises to supply fill for the square-sets, in addition to the normal development work. Using filling supplied through waste raises from the level above, miners spent at least one-third of their time preparing to fill or filling the square-set. Other difficulties typical of the low production method were the additional timber and time consumed in reinforcing the sets in place to hold the heavy ground so that complete extraction of ore could be



General plan of fifth mining floor above the 1300 Level of the Fortune vein. To give idea of area shown, each square represents a timber set on five-ft centers. Below the 1200 Level this ore has been mined by the combination method.

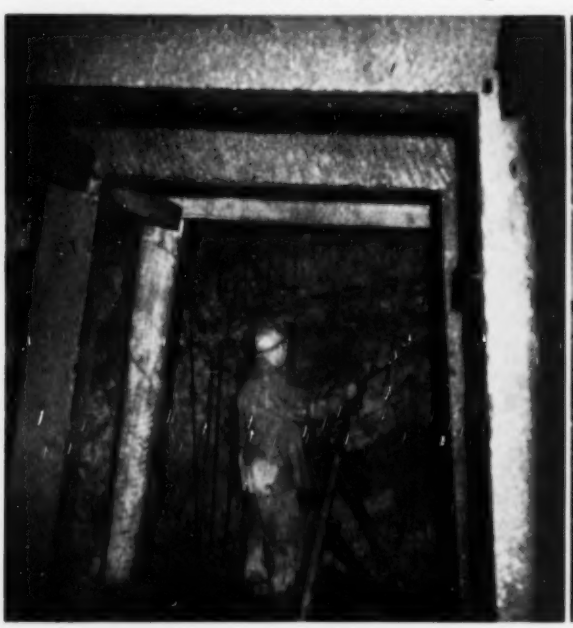
made. In a typical period, 1947 through 1950, the average tons per man-shift were only 5.59.

Geology

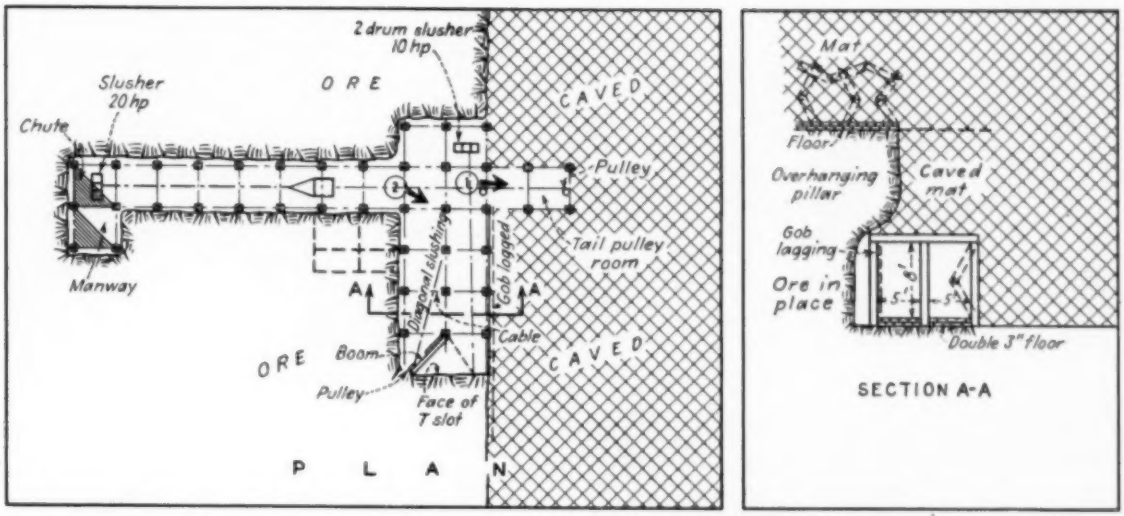
In planning a mining program such as this it is necessary to have basic understanding of the geology of the orebody. Favorable factors involved in considering use of this stoping system include easily caved ground and an orebody wide enough to permit free descent of matting and gob. Most ground which is mined by square-sets would qualify under this system.

In the area being mined by this method at the present time, the orebody occurs in flat lying sedimentary rocks consisting of 60-ft thick bed of Peerless shale, made up of alternating beds of shale and sandy limestone and the upper 40 to 50 ft of the Sawatch quartzite, a massive vitreous quartzite. The ore is in the hanging wall of the Fortune fault, a strong structure striking north and dipping 70 to 80 degrees to the west. This orebody has been mined extensively in the upper levels. The ore occurring in the Peerless shale is largely sulphide replacement of lime beds in the formation, while in the quartzite the mineralization is a stock work of veinlets. The quartzite has been intensively fractured by movement along the fault, particularly where a system of parasitic structures striking N 25° E, and dipping west, intersect the Fortune fault. The footwall of the orebody consists of a soft, highly altered rhyo-

Initial development stages of a new mining floor, driving the slusher drift connecting two raises. Equipment in photo is standard for slusher drifts and crosscuts. Single-use bits are used with the handheld drills and air legs.



Gob and waste rock along the rib of new crosscut being driven to hanging wall. Blasting had damaged the lagging on the set, but difficulties were not encountered.



Idealized plan and section of the mining system at work. Section shows crosscut ready for caving with gob lagging in place. Pictures at bottom of page correspond to numbers and arrows on drawing at left, having been taken from same positions.

lite dike which follows the Fortune fault and the mineralization extends from this dike out into the hanging wall for a width of 40 to 120 ft.

Details of New Mining Technique

Starting from the 1300 Level haulage drift on 100-ft centers, two compartment raises were driven to the 1200 Level, timbered and lagged to provide ingress for subsequent mining. Raises were located about 40 ft from the footwall in the ore.

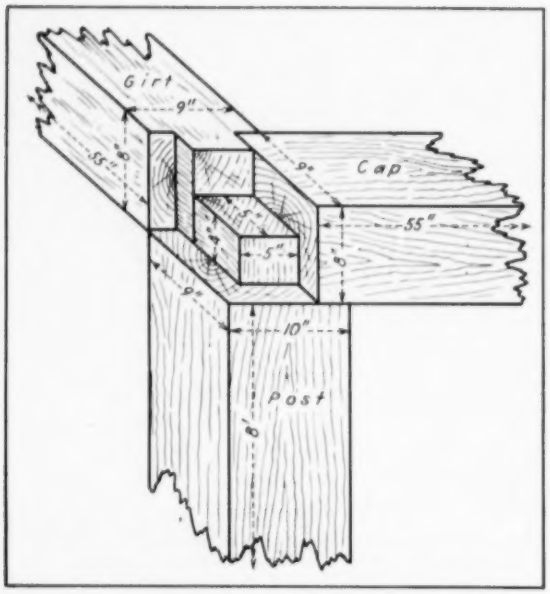
The service raises were connected at the top by drifts, that not only served for ventilation, but also as slusher drifts for removing the initial slice of ore lying under the old 1200 Level stopes. This first cut was taken out by typical top-slicing methods so that better control of the caving could be maintained when breaking into mined out areas and preparing the initial mat. Considerable amounts of old timber were introduced as backfill in this first floor to alleviate difficulty with fast caving of lower sub-levels. Fast, uncontrolled caving results in dilution and poor extraction.

The standard pattern of slusher drifts and crosscut slices or tests as shown on the 5th level plan was used to excavate the first floor as well as the lower sub-levels.

After completing the top floor or advancing it to the point where mining on the next sub-level would not disturb it, a second floor was commenced 19 ft below. The slusher drift was driven across to the

View from position No. 1 as marked on drawing above. End of slusher drift as it caves in retreat. Three sets are kept open to give clearance for tail sheave of 20 hp hoist.

View from position No. 2 on drawing at top of page. Starting new crosscut drift. Gob lagging is visible against the caved area. Note weight on post at extreme left, where cap is mushrooming post.



Framing of typical crosscut or tee-drift timber. Note provisions made for standing duplicate set on top of the sill set in cases where mat will not support back long enough to remove ore.

adjoining raise of the next stope and crosscut slices were excavated from hanging wall to footwall perpendicular to the slusher drift. Length of the crosscut tee varies from 15 to 125 ft.

When a tee has been mined out two or three sets wide to the extremeties of the orebody, the timber is gob-lagged against the ore in place with 2x12 in. lagging. At this point, caving of the 9-ft back pillar, i.e., between the back of the new sub-level and the floor of the one above, is started, retreating toward the slusher drift. As the pillar is removed, the mat from the level above drops slowly, allowing the ore to be removed. In cases where posts and caps fail to crush in the retreat, posts are blasted out to kept mat following the retreat. It will be noted that only one half of the pillar over the tee next to the unbroken ore is removed. This prevents dilution from pulling under the pillar when the next tee is caved.

Retreating along the slusher drift toward the ore chute and service raise, tees are driven in the same manner to remove the 20-ft layer of ore between the two sub-levels. The small 10 hp slusher hoist used in the crosscuts is moved along with the retreat, but by utilizing a narrow (30-in.) scraper, broken ore from as many as three slots can be removed with re-positioning of the hoist. Diagonal slushing, using a boom for the tail sheave, is the most economical method for transporting the rock from the slices into the main slushing drift.

Timber and Equipment

The connection or slusher drifts are driven for standard 10x10-in. drift sets with 9-ft posts and 6 ft 4 in. caps placed on 5-ft centers. This drift accommodates a 20 hp slusher hoist and a 42-in. scraper for driving and later transfer of mined ore to the chute raise. Sets are securely lagged and blocked to minimize maintenance for the life of the sub-level.

In crosscut slots, the standard support is 10x10-in. material for 8-ft posts, caps and girts, set on 5-ft centers both ways. To build up the mat carried along with the mining, particularly in the upper portion of the stope where the wall rock is weak Peerless shale, crosscut slots are floored with two thicknesses of 3x12-in. timber.

Ventilation in this mining method is good since there is usually a complete loop open for circulation, but strategically situated blowers maintain a positive flow of fresh air.

Variations in Mining

Irregularities and variations in the ore require changes in the standard procedure to maintain the lead-zinc combination. When uneconomical ore is encountered in the center of the mineralized zone, the extraction procedure is altered. For example, a low grade pillar lies along the slusher drift, but it is desirable to reclaim ore behind the pillar, and six or seven sets toward the footwall. A slot, one set wide is driven from the slusher to the footwall, and then with tees, parallel to the slusher drift, the ore is extracted along the footwall. The overhead pillar is blasted and removed, retreating back to the main slusher drift, leaving the low grade pillar between the crosscut slots.

The higher grade ore occurs on the footwall against the soft rhyolite, which tends to swell and run, making extraction difficult. Although efforts are made to mine this section rapidly, difficulties are experienced in making a high recovery. On occasions, it is necessary to remove the overhead pillar and stand another set of timber above the sub-level floor to control the movement of this rhyolite.

Also, consideration must be given to location of the first tee driven from the slusher drift. Generally, the starting point is at the far end of the slusher drift, but when the one is over 50 ft wide, the teeing is started halfway between the raises, retreating both ways to the chute raises. Because of the increased amount of ore in the wide ore zone, two crews work the sub-level simultaneously.

Advantages

The changeover from square-set to sub-level mining has brought about a number of favorable situations for lowering the mining costs.

Ground support methods account for a large portion of the total savings. Nearly 50 pct of the timber is eliminated since only on rare occasions is it necessary to support the area occupied by the back pillar. Upon commencing retreat, no filling or other means are required to hold the area open.

Increased production per man-shift has not only reduced the crew, but permits consolidation of working places for better production and supervision. Increased production also allows the contract miner to move his own slushers and do the dead work, in addition to drilling, blasting, timbering and slushing.

Summarizing the apparent advantages:

1—Continuous mining without shutdowns to gob.

2—Reduced timber cost, reduced labor cost for timbering.

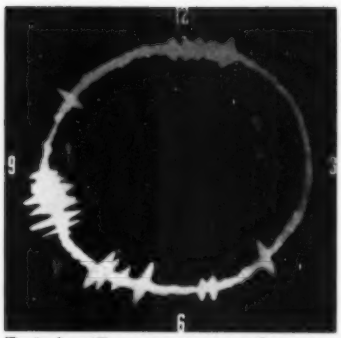
3—Better ground control. (A cave or run can be controlled easily—losing at most only a small percentage of the mineable ore.)

4—More men working in a smaller area. (This simplifies supervision, supply delivery, haulage, and reduces haulage maintenance.)

5—Safer mining.

6—More flexible mining.

7—Less skilled miners required.



Typical oscilloscope pattern on the stratascope. Blips indicate harder layers, guide operator in remote control of cutting head.

Coal by Remote Control

Launching Platform — Drift Indicator— Stratascope—are components of Carbide and Carbon Chemicals new Mining Machine No. 3.

EVIDENCE that mining has caught up with the era of rockets, radar and remote control, is contained in Carbide & Carbon Chemicals new mining machine. C&CC, subsidiary of Union Carbide, has come up with a unit reaching more than 700 ft underground, delivering a ton or more of coal to the surface per minute.

Without a man being underground, this machine has produced up to 1240 tons per day, 6000 tons per week. Electronic controls permit machine either to delve deep underground from the surface, or to extend for hundreds of feet the effective radius of underground workings.

It all started many years ago when Union Carbide began search for new sources of chemicals. Coal gasification projects called for a machine to bore small holes to the coal beds. There were difficulties with gasification, and mining machine No. 3 was born when engineers decided, 'the coal was worth more than the holes.'

The unit now in use is part of an integrated mining system, suited to the West Virginia hill country, where relatively flat lying seams are exposed on both sides of the ridges. The launching platform, which carries the control cab, shifts itself along a bench cut into the hillside.

The bench serves as a site for the launching platform, as a road for hauling away mined coal, and as a means of exposing a fresh coal face.

At each hole site the launching platform is levelled, the machine is started into the bank, taking out a 38x116-in. hole up to 700 ft underground. Coal is carried out behind the machine on a string of portable conveyors. As the machine advances 15 to 24 in. per min up to two tons of coal is delivered to the surface per min. Every 30 ft another conveyor is attached. When the hole is complete the machine backs itself out, drops down to take another cut if the seam is thick, or is shifted to the next site.

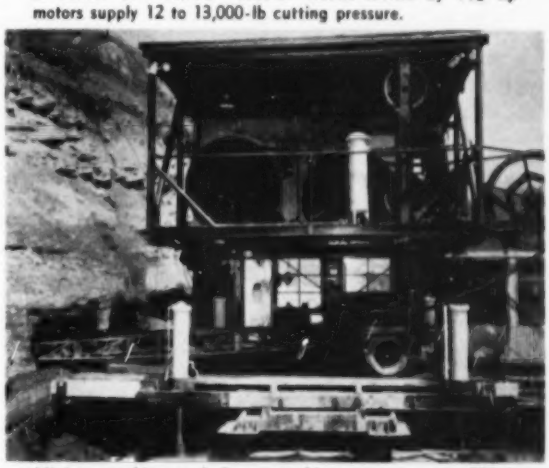
Extraction of 65 pct may be achieved with 36-in. pillars. Pillar width is measured by boring an auger hole through the pillar to the adjacent hole. This is done automatically, dials indicate pillar thickness. Directional controls for the cutter head are among instruments facing the operator.

Engineers stress that C&CC has no desire to manufacture mining equipment, that this is a development model. But, it can be called a success from the 150,000-ton coal pile it has produced. Plans for a more advanced unit call for more power at certain points and up to 1000 ft operating depth.

Spokesmen pointed out that costs were a guess at this stage, but that guess appeared to be up to a 40 pct saving in coal mining costs.

Outermost cutters teeth carry sensing teeth, send pulses back to stratoscope mounted in operating cab.

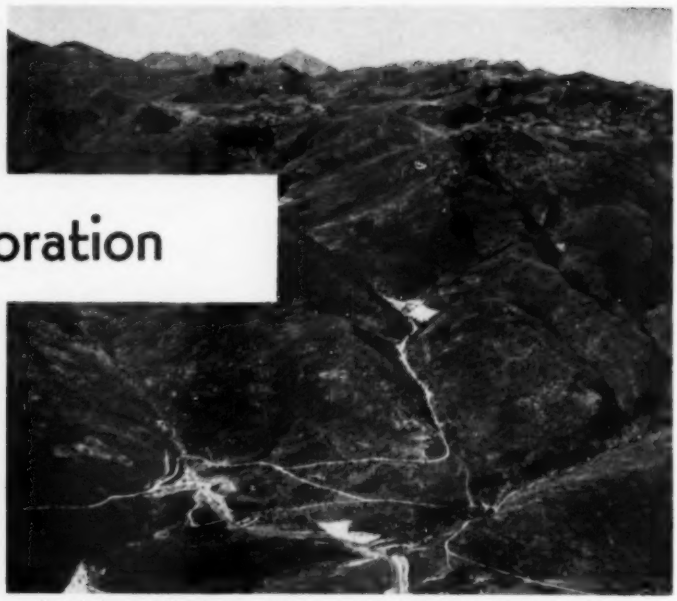
Four intermeshed cutting heads have 120-hp drive. Paddles behind cutters (see close-up above) force coal to conveyor in center of machine. Tractor treads driven by 7½ hp motors supply 12 to 13,000-lb cutting pressure.



Mining machine and first portable conveyor start 700-ft trip underground. Holes and pillars show in bank. The 14-wire power cable and 57-wire control cable follow machine underground. Operator is in cab at extreme right.

Testing Geophysical Exploration Methods

by Ray E. Gilbert



Aerial photo of Mayflower mining area of New Park Mining Co. Lower left, Mayflower tunnel, center, Park Galena and Start of Utah tunnels. Extensive soil cover and rugged terrain make geophysical methods attractive.

IN what ways can conventional geophysical methods be used in the search for quartz-sulphide veins covered by several feet of overburden? The New Park Mining Co., in search of an answer to this question, empirically tested simple geochemical, electrical, and magnetic methods over known ore bodies and geologic structures. Geochemical methods were the only ones found to be applicable to direct ore search. Indirect uses were found for electrical and magnetic tests.

Experiments were conducted in the southeastern part of the Park City mining district. Ore in this part of the district is found principally in steeply dipping veins which are localized along faults and fractures that cut Paleozoic sediments and quartz diorite intrusives. Extensive soil cover effectively hides both veins and country rock.

The type of vein most likely to be as yet undiscovered is quartz, with varying amounts of calcite, pyrite, sphalerite, and galena. The sulphides will not be in sufficient quantity to form the continuous conductor desirable in electrical prospecting. Argillic and sericitic alteration can be expected to form a thin envelope around the quartz, but total vein width, including the alteration halo, is generally less than 10 ft. Wallrock may be quartz diorite, limestone, or quartzite. Soil cover will range from 5 to 30 ft in thickness.

Two productive veins in New Park's Mayflower mine have near-surface characteristics similar to those described, and have been used as geophysical "guinea pigs" in most of the tests. Commercial ore in one of the veins comes to within 50 ft of the surface. The top of commercial ore in the second vein is 1000 ft below the surface, but low grade lead-zinc mineralization extends up to the outcrop.

Soil sampling in the Park City district definitely has value as a direct method of outlining halos of zinc-rich residual soil covering near-surface ore. It also appears to be an indirect method of distinguishing between mineralized and barren areas.

RAY E. GILBERT is geologist, Day Mines, Inc., Wallace, Idaho.

Geochemical Prospecting

Samples of soil are taken in the area being prospected, and their zinc content is determined by simple colorimetric test. Zinc was chosen as the indicator metal because it is present in all Park City ore, and because its determination is fast and easy. Sampling of soil instead of bedrock was dictated by the extensive soil cover and the resulting sparsity of rock outcrops.

Most of the soil can be considered residual, if allowance is made for the downhill creep caused by generally rugged topography. Water transported material is present in the canyon bottoms.

Early tests were made over the suboutcrops of the two producing veins in the Mayflower mine. The anomalies found in the soil cover indicate quite conclusively that zinc mineralization can be detected, if the mineralization has been exposed to erosion, and if the soil is residual. Cross sections of the veins, Figs. 1 and 2, show the downhill displacement of the anomalies caused by soil creep. Consideration of topography is essential in interpreting soil anomalies.

High zinc content of the alluvium in the gulch bottom also shows in Fig. 1. This alluvium contains material eroded from the outcrops of both veins. Testing of alluvium is clearly suggested as part of the preliminary sampling of a new area. Distinction between transported and residual soil is important in analyzing any anomalies.

A zinc anomaly not directly related to the vein is shown in Fig. 2. This is caused by a clay-limonite zone containing noncommercial amounts of zinc. This mineralization is so near the Mayflower vein that a close relationship is suggested, but the same type of clay-limonite-zinc mineralization has been found in a number of places at considerable distances from any known ore. Consequently, it is not

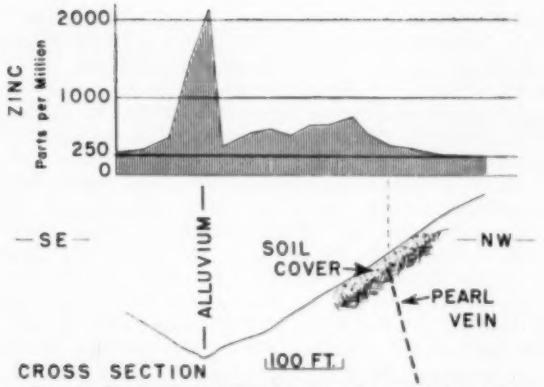


Fig. 1—Geochemical prospecting reveals anomalies over known vein, shows soil creep. Alluvium at gulch bottom shows very high zinc content.

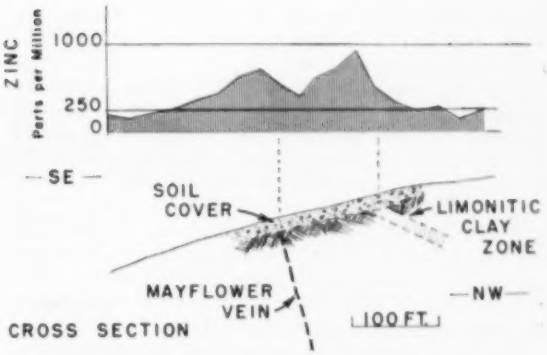


Fig. 2—Zinc anomalies show over vein and limonitic clay zone. Evaluation of anomalies over clay-limonite zones is major problem in applying this technique.

known whether this mineralization has a more than coincidental association with commercial ore.

The correct answer to the clay-limonite-zinc mineralization is extremely important in the application of geochemical prospecting in the Park City district. Zinc halos caused by weathering of the limonitic clay are often larger in area and higher in value than those caused by vein erosion. They can easily obscure a vein anomaly. If they do not have a definite relationship to commercial mineralization, they might bring about the exploration of economically hopeless areas. However, until more is learned about the problem, it seems reasonable to assume that the presence of low grade zinc is indicative of a generally mineralized area, and that there is a possibility of finding commercial ore within that area.

Even with the clay-limonite anomalies it is possible to classify extensive areas as unlikely to contain near-surface ore. Soil sampling thus focuses further exploration on comparatively small sections. Trenching, diamond drilling, or crosscutting must follow, to test the geochemical anomalies.

Resistivity Methods

Simple resistivity tests were found to have no value in the direct search for near-surface veins. They do have a limited use as an aid in working out certain structural problems. Faults can be traced where they mark the contact between rocks of different resistivity, and contacts between intrusive and sedimentary rocks can usually be located.

An easily portable direct current outfit with porous pot electrodes was used in the resistivity tests. One profile was checked with much heavier Gish-Rooney commutated dc equipment and metal stake electrodes. The results were almost identical, so the lighter equipment was used thereafter.

Two straight line electrode configurations were tested. One was the Wenner, with four equally spaced electrodes. The other was the Lee partitioning method, differing from the Wenner by the addition of a fifth electrode at the midpoint of the configuration. In order to smooth out changes in apparent resistivity caused by overburden variations, it was necessary to use an electrode spacing of at least 25 ft (total spread of 75 ft). Usually a 50 ft spacing seemed better.

Neither configuration indicated the location of either of New Park's veins. This is believed to be caused by a combination of the narrow width of the vein compared to the electrode spacing, of the overburden thickness, and of the small difference between the resistivity of the vein and the wall rock.

Either configuration satisfactorily measured the apparent resistivity of the underlying rock. The Wenner method is preferred because it uses only four electrodes and requires fewer calculations. Resistivity measurements have been used to locate diorite-quartzite and diorite-limestone intrusive contacts, a quartzite-shale fault contact, and a limestone-shale bedding contact.

Self-Potential Methods

Self-potential methods appear to be of little or no value in prospecting in the Park City area. The causes of some observed anomalies are not clearly understood, but it is quite certain that they are not indicative of mineralization.

Self-potential measurements were made with conventional equipment and procedure. No anomalies were found over either of New Park's veins. A weak positive anomaly was recorded 100 ft in the hanging wall from one vein, and roughly parallel to the vein. The anomaly is coincident with a comparatively flat grassy slope, which is in contrast to steeper timbered slopes around it. It is felt that the anomaly is caused by the differences in surface features, rather than by the vein structures.

Negative anomalies were found at some points along contacts of different rock types. A typical example is shown in Fig. 3, where quartzite forms a thin capping over diorite. The anomalies are present near either edge of the quartzite cap. But they

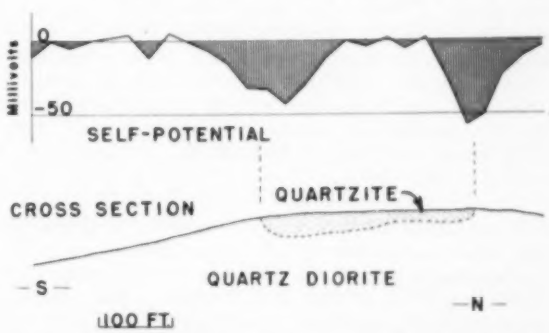


Fig. 3—Negative anomalies at contacts of different rock types, shown by self-potential method, did not follow contact, but formed around certain points of the contact.

do not follow the contact in a linear manner. Instead, they have a crudely circular form around certain points along the contact.

A similar occurrence was found where limestone forms a capping along a ridge crest, with shale beds beneath. A cross section of this would be similar to that in Fig. 3. The limestone-shale contact is nearly horizontal, and negative anomalies are near the contact. The shales contain very little pyrite. Two of the anomalies were measured in September 1947 and again in June 1948. Their magnitude decreased from 250 millivolts in the fall, when the ground was dry, to 100 millivolts in the spring, when the ground was wet.

The cause of these contact anomalies is not known. They have been checked by soil sampling, which indicated an absence of zinc mineralization.

Magnetic Methods

Measurement of vertical magnetic intensity was found to be of no value in the direct search for near-surface veins. Two indirect applications are suggested for magnetic methods. One is the indirect location of faults by mapping offsets of dikes having a high magnetic susceptibility. The second is the determination of the thickness of andesite flows that cover a large area immediately east of the Park City district.

A vertical intensity variometer with a scale constant of about 13 gammas per scale division was used for the work in the New Park area.

A single magnetic profile was run across the outcrops of New Park's veins. No anomalies were found, and because there was no theoretical reason to expect any different results, work over the veins was discontinued.

Most rocks in the area have a uniformly low magnetic susceptibility. This is true of the principal quartz diorite mass as well as for the sediments. Consequently, it is not possible to pick diorite-sediment contacts with any certainty.

A few dikes, later, and somewhat more basic than the quartz diorite, have a much higher magnetic susceptibility. Anomalies up to 1,500 gammas were found over these dikes. An indirect way to detect post-dike faulting (possible ore channels) is suggested in areas in which the dikes are found. This can be done by use of the magnetometer to map the dikes and any displacement of the dikes caused by faulting.

Andesite flows blanket the eastern side of the Park City district. These volcanics have a much higher magnetic susceptibility than the underlying sediments. O'Toole has done some work to show that the magnetic anomalies are probably proportional to the thickness of the flows. This fact can be used to locate areas in which the sediments have only a thin volcanic cover. Plans for exploration of the area east of the present district may make this information desirable in the future.

Other Methods

Biogeochemical prospecting, the determination of the trace-metal content of plants, was briefly investigated, but dropped in favor of soil sampling. Plant sampling, in the Park City area, has several disadvantages as compared to soil sampling. No one kind of plant has a sufficiently wide distribution to be used as the sole sample source. Comparison of the trace-metal content of different plants from point to point is unsatisfactory, because of the variance in metal content of different plants even when growing side by side. Much experimental work must be done to determine the effect of soil type, season, and climate on the metal content of plants, before biogeochemical prospecting can be applied with certainty.

Gravimetric prospecting was considered and then discarded on theoretical grounds. The density of run-of-the-mine ore differs from that of the country rock by less than 20 per cent. This fact, together with the narrowness of the veins, would produce a very small anomaly. Gravity differences caused by variations in overburden thickness could be expected to obscure any vein anomaly. Because of the rugged relief, terrain correction would be difficult, and subject to errors that would tend to further obscure any ore anomalies.

Electromagnetic methods have never been tried, because of the lack of equipment and experienced personnel. It is hoped that such methods can be tested over New Park's quartz-sulphide veins in future exploration.

Conclusions

As applied specifically in the Park City district, it can be said that geochemical prospecting is useful in the direct detection of near-surface ore, as well as in outlining general areas of mineralization. Magnetic and resistivity methods are useful in working out special structural problems, but are of little use in direct ore search. Self-potential, biogeochemical, and gravimetric methods appear to be of little value in either structural or ore problems. Electromagnetic prospecting has not been tried, but it is hoped that it can be tested in the future.

Viewed in a general way, geophysical exploration methods should be considered as tools of the mining geologist, comparable to the diamond drill. Location of a diamond drill hole is based on a careful geologic study. The hole has a definite objective. The capability and limitations of drilling, as applied to the particular problem, are understood. Geophysical methods should be used in the same way. First, geologic information should be assembled into as complete a picture as possible. Then geophysical methods should be chosen to solve specific problems existing in the picture. Selection of the methods used should be based on a sound understanding of their capabilities and limitations.

The cost and expected results of the planned geophysical work should be compared with those of any other available testing methods—drilling, trenching, tunneling. Choice of any method finally used should depend on a consideration of the combination of cost and expected results. Thus used, geophysical prospecting can be valuable to the mining geologist.

Acknowledgments

The geophysical experiments were inaugurated and encouraged by W. H. H. Cranmer, President and General Manager of New Park Mining Company. H. V. W. Donohoo, formerly with the Geophysics Department of the University of Utah, gave valuable technical help in the field and in the interpretation of the data collected. H. R. Bradford, University of Utah analyst, kindly ran many spectrographic analyses of plant samples. Roy P. Full, of the Department of Mining Engineering at the University of Utah, suggested improvements in expression and form.

Annual Meeting:

TECHNICAL PROGRAM

See Page 89 and 91 for other Annual Meeting Information

MONDAY FEBRUARY 16

MINING

Morning

Special Mining Problems

An Analysis of Mine Opening Failures by Means of Models by Bernard York and John Reed.

Underground Radio Communications in Lake Superior District Mines by E. W. Felegy.

Mine Drainage at Eureka Corporation, Ltd., Eureka, Nevada by George W. Mitchell.

Fan Performance and Selection Using Dimensionless Ratios by I. Hugh Hamilton, et al.

Determination of Ground Movement by L. Obert, W. I. Duvall and H. Byrne.

Afternoon

New Mining Developments

Stripping a Small Orebody Preparatory to Mining by P. W. Lewis.

St. Joseph's Indian Creek Development by C. Kremer Bain.

Resurrection Mining Company at Leadville, Colo. by John Wright and C. N. Stout.

Report on Long Hole Blast Drilling for Pillar Extraction at the Torbnit Mine by Harry Babty.

GEOLOGY & GEOPHYSICS

Afternoon

Joint Session Geophysics and Geology

Gravimeter Surveys for Residual Banite Deposits in Missouri by LeRoy Scharon and R. P. Uhley.

Application of Multiple Frequency Electromagnetic Exploration to Mining by S. H. Ward.

Significance of the Pleistocene Series in the Groundwater Resources of Illinois by John W. Foster.

Correlations of Aeromagnetics and Rock Formations in Minnesota by G. M. Schwartz.

MINERAL ECONOMICS

Afternoon

Paley Report

Objectives by Arthur H. Bunker.

Analyses of Principal Controversial Issues

(1) *Tariffs* by L. C. Raymond.

(2) *Public Land Policy* by C. Jay Parkinson.

(3) *Price Stabilization and Buffer Stocks* by Miles P. Romney.

INDUSTRIAL MINERALS

Morning

Potash Symposium

Processing and Milling at Duval Sulphur & Potash Co. by G. E. Atwood and D. J. Bourne.

Processing and Milling at International Minerals & Chemical Co. by G. T. Harley and Carl A. Arend.

Processing and Milling at Potash Co. of America by E. A. Schoeld.

Carlsbad Potash Industry and Geology of Deposits by G. E. Atwood and D. J. Bourne.

Afternoon

Mining Methods in Carlsbad Area by R. Haworth.

Main Plant Cycle at American Potash & Chemical Corp. by M. L. Leonardi.

Economic Phases of the Potash Industry by R. W. Mumford.

Geology of Searles Lake and Its Age Determination with Carbon 14 by W. A. Gale.

Leasing of Government Potash Land by H. I. Smith.

Afternoon

Joint Meeting with Society of Economic Geologists

Dimension Stone Industry of California by L. A. Norman.

Quarter Century of Granite Quarrying in Massachusetts by Ralph Fletcher.

Rock Bursting and Other Geologic Problems in the Granite Quarries of Barre, Vt., by R. H. Jahns.

Quarry Practices in the Indiana Building Stone Industry by Richard Letsinger.

Stratigraphy and Composition of the Salem Limestone by John B. Patton.

Dimensions Stone in the United States in 1952 by C. F. Deiss.

MINERAL BENEFICIATION

Afternoon

Crushing and Grinding

Design Development of Crushing Cavities by H. M. Zoerb.

Crushing Plant Dust Control at Ray Mines, Kennecott Copper Corp. by J. F. Knudsen.

Work Indexes Tabulated (Impact and Compression Data, Rod and Ball Mill Grindabilities by F. C. Bond.

Multiple Stage Grinding and Classifying Circuit for Fluorspar by Durwald Spees.

COAL

Morning

Mining Western Coals

Exploration of the Oaxaca Coal Field in Southern Mexico by Cortés Obregon and Luis Torón, Bank of Mexico.

Underground Mining and Preparation of Coal at Sunnyside, Utah by Wesley Hyatt and R. G. Heers.

Western Coal Mining by A. M. Keenan.

Afternoon

Preparation—Dewatering and Dense-Medium Cleaning

Reducing the Moisture Content and Large Moisture Variations in Russellton Washed Coal by Orville R. Lyons.

Cleaning Various Coals in a Dense-Medium Pilot Plant by M. R. Geer, Wm. A. Olds, and H. F. Yancey.

Trends in the Application of Float-Sink Separation for Coal Cleaning by Carl S. Westerberg.

Procedures for the Evaluation of Fine Coal Cleaning Plants by H. J. Donald and C. C. Wright.

EXTRACTIVE METALLURGY

Morning

Copper

Effect of Chloride on the Deposition of Copper in the Presence of Antimony and Arsenic by V. Hospadaruk and C. A. Winkler.

New Cornelia Copper Smelter of the Phelps Dodge Corp. at Ajo, Ariz. by J. W. Byrkit.

Afternoon

Copper (Cont'd)

Rehabilitation of Asarco's Perth Amboy Copper Refinery by G. H. Weis, D. A. Busch, H. K. Spaulding, G. B. Spaulding.

Anode Casting at the Garfield Smelter by N. Alston, M. J. Winkel.

Arc Furnace and Its Operation at the Kennecott Utah Refinery by H. A. Shaw and H. G. G. Whitton.

Afternoon

Lead and Zinc

Strontium and Barium Salts for Control of Lead Content of Electrolytic Zinc by A. C. Jephson and G. D. Stendahl.

Sintering Zinc Concentrates on the Blackwell 12x168-Ft Machine by A. E. Lee.

New Jersey Zinc Co.'s Sterling Process by W. M. Pierce.

TUESDAY, FEBRUARY 17

MINING

Morning

Cast Cutting Developments

Use of Wooden Rock Bolts by Rollin Farmin.

Use of a Caved Block as an Ore Pass and Its Application to Open Pit Mining by H. Carrol Weed.

National Lead Co.'s Mechanization at Fredericktown, Mo. by Harold Krueger.

Block Caving at Bunker Hill and Sullivan by Charles Schwab.

Afternoon

Non-metallic Mining

United States Gypsum Co. Mine, Heath, Mont. by G. C. Mathis.

International Salt Mine, Detroit, Mich. by C. E. Holder.

Carey Salt Mine at Hutchinson, Kansas by S. B. Horrell.

GEOLOGY

Morning

Relation of Geology to Exploration, Develpoment and Appraisal

Importance of Geology in the Exploration of the Blackbird Cobalt District by John S. Vhay.

Sampling of the Greater Butte Deposits and Its Application to Mine Evaluation by E. P. Shea.

Role of Geology in the Development of the Iron Ore Deposits in Labrador by J. K. Gustafson.

The Importance of Geology in Appraisal of Mineral Properties by Harrison Schmidt.

Afternoon

Pb-Zn-U

Geology of the Shoshone Mines, Calif. by M. B. Kildale.

Geology as Applied to Mining in the Wisconsin-Illinois-Iowa Lead-Zinc District by A. F. Agnew.

Progress in the Study of Lead-Zinc Gossans by Chas. H. Behre, Jr. and W. C. Kelley.

Igneous Geology, Structure and Uranium Mineralization of the Central Area, Antelope Range, Utah by F. C. Christiansen.

Hydrothermal Alteration Accompanying Tertiary Uranium Deposits by P. F. Kerr, G. P. Brophy, H. Dahl, J. Green and L. E. Woolward.

Geology of Uranium and Vanadium of the Colorado Plateau by C. A. Rasor.

MINERAL ECONOMICS

Morning

Joint Session with Extractive Metallurgy

The Production Expansion Program for the Aluminum Industry by S. W. Anderson.

Outlook for Magnesium Production by F. J. Krenzke.

Economic Importance of Pegmatite by P. M. Tyler.

Afternoon

Mine Evaluation

Area of Conflict Between Oil and Mining Activities on Public Lands by H. B. Mock.

Financing of Domestic Mines by C. C. Bailey.

Changing Factors in Mine Evaluation by S. H. Dolbear.

INDUSTRIAL MINERALS

Morning

Joint Session with Society of Economic Geologists

The Synthesis of Industrial Gems by Clifford Frondel.

The Monazite Deposits of the Carolina Piedmont by John C. Mertie.

The Geochemical Association of Columbium and its Geological and Economic Significance by Michael Fleischer.

Minor Element Accumulation in Coal Ash and Its Economic Implications by Taisia Stadnichenko.

Mining and Milling of Complex Pegmatite at Kings Mountain, N. Car. by F. S. Shay.

Afternoon

Joint Meeting with American Ceramic Society

Quality Control by the Talc Producer by Wardie W. Gaskins.

The Importance of Uniform Talc in Ceramic Tile Manufacturing by Charles P. Brady.

Quality Control by a Ball Clay Producer by Probert W. Daber.

Control of Clays and Talcs in Casting and Jiggering of Ware by Myles P. Bennett.

Mining, Uses and Specifications of Some Vermont and New York Talcs by Victor Backles.

Selective Mining of Georgia Kaolins by S. G. Maguire, Jr., W. L. Rider and M. L. Jontz.

Afternoon

Mineral Aggregates

Bloated Shale Aggregate in the Pacific N. W. by A. O. Bartell and Robert E. Brooke.

Crushed Limestone Aggregates for Concrete by Mrs. Katharine Mather.

Alkali Reactivity of Natural Aggregates in Western U. S. by Wm. Y. Holland and Roger H. Cook.

Use of Soniscope in Dynamic Testing of Concrete by Mr. Tye.

Rodmill Grinding for Fine Aggregates by R. S. Barneyback.

MINERALS BENEFICIATION

Morning

Solid-Fluid Separation

Centrifuging as Applied to the Metallurgical Industries by Bird Machine Co.

Centrifuging and the Metallurgical Industries by Charles Ambler.

Application of Centrifugal Force to Increase the Efficiency of Gravitational Classifiers by Donald A. Dahlstrom.

The Centriclone in Specific Metallurgical Applications by Donald A. Dahlstrom.

Morning

Materials Handling

Moving a 2000-ton Concentrator and Supporting Town 165 Miles by Sherritt-Gordon Co.

Rubber Coating of Materials Handling Equipment by Galigher Co.

Wet Phosphate Rock Storage and Handling by G. L. Lyle, Jr.

Coordinated Process Control—Cost and Benefits by H. C. Frost.

Afternoon

Education Session Jointly with Extractive Metallurgy

What Industrial Organizations Are Doing to Select New Technical Employees by F. R. Morral.

Selection of Students for Study of Metallurgical Engineering by Joseph Newton.

Desirable Qualifications of Metallurgists from Standpoint of Industrial Employers by Frank Wickhorst.

Summer Employment Program of Minerals Beneficiation Division by H. Rush Spedden.

Afternoon

Solids-Fluids Separation

Horizontal Filter as Applied to the Metallurgical Industry by Oliver United Filters, Inc.

Application of the Dewatering Screen to the Metallurgical Industries by W. S. Shira.

Magnetic Separators Related to the Concentration of Magnetic Iron Ores and Recovery and Cleaning of Magnetic Media in Heavy Media Processes by W. A. Newton.

Operating Behavior of Liquid-Solid Cyclones by E. B. Fitch and E. C. Johnson.

COAL

Morning

Utilization and Preparation

The Blending of Western Coals for the Production of Metallurgical Coke by John D. Price.

Correlation Coefficients for Evaluating the Relative Value of Coke Physical Tests by R. W. Campbell.

Fundamental Considerations in Drying Fine Coal by G. A. Vissac, Consulting Engineer.

Hypothesis for Different Floatabilities of Coals, Carbons, and Hydro-carbon Minerals by Shiou-Chuan Sun.

Afternoon

Mining—Handling Materials and Ventilation

Two-Way Belt Transportation by C. W. Thompson, Weirton Steel Company Division.

Sizing of Bleeder Pipes for Mine Seals by Raymond Mancha.

Materials Handling in Coal Mining by R. U. Jackson.

EXTRACTIVE METALLURGY

Morning

Pb-Zn Session

Chihuahua Zinc Fuming Plant by V. R. MacDonald.

Vacuum Dezincing of Desilverized Lead Bullion, Broken Hills Smelter by T. R. A. Davey.

Development of a Continuous Updraught Sintering Process by W. R. Burrow.

Description of National Lead Co.'s Antimony Smelter at Laredo by J. C. Archibald, R. K. Kulpaca.

Afternoon

Aluminum-Magnesium

Experimental Production of Alumina from Anorthosite at Laramie, Wyo. by H. W. St. Clair.

Use of Gas Engines in the Aluminum Industry by R. W. Bayerlein.

Cost Factors in Utilization of Foreign Bauxite by A. Johnson.

WEDNESDAY, FEBRUARY 18

MINING

Morning

Iron Mining

Mt. Hope Mine, Warren Pipe & Foundry Co. by Allen James.

Eagle Mt. Iron Ore Operation by K. B. Powell.

Bethlehem Cornwall Corp., Cornwall, Pa. by S. J. Shale.

Ozark Ore Co. Iron Mine, Iron Mt., Mo. by W. F. Shinners.

Afternoon

Shaft Sinking Symposium

Arranged by C. W. Nicholson and W. R. Atkins.

GEOLOGY

Morning

Joint Session with Engineering Geology Div., G.S.A.

Notes on Landslide Control Methods in Oregon by L. E. Scott.

Flood Caused by Bursting Glacial Lakes in the Peruvian Andes by Parker Trask.

The Subsidence of Long Beach Harbor and Corrective Procedures by R. R. Shoemaker.

Geology of Folsom Dam by C. P. Holdredge.

Bridge and Structure Foundations in California.

Afternoon

General Session

Mineral Industries of California by Olaf P. Jenkins.

Current Activities in the Mineral Industries of Algeria by Richard Anderson.

Localization of Pyro-Metasomatic Ore Deposits at Johnson Camp, Ariz. by Arthur Baker, III.

Wall Rock Alteration as a Guide to Exploration North of Tonopah by A. T. Broderick.

Geology of the Potash Deposits, Carlsbad, N. Mex. by C. L. Jones.

GEOPHYSICS

Morning

Aerogeophysics

The Airborne Magnetometer—A Documentary Film by U.S.G.S.

Comparison Between Airborne and Ground Magnetometer Surveys in Mineral Exploration in the Canadian Shield by T. Koulomzine, P. R. Groffroy and J. V. Fox.

Discussion of Paley Report as it Effects Geophysical Exploration by F. W. Hinricks.

Airborne Radioactivity Surveying by W. L. Morris.

Low-Level Airborne Radiometric Surveying in the Colorado Plateau Area by R. S. Foote.

Multilevel Aeromagnetic Profiles Over Ore Bodies and Their Interpretation by Wayne Hoylman.

Afternoon

Ground Geophysics

Use of Small Diameter, Scintillation Type, Drill Hole Logging Unit for Radium Ore Detection by R. S. Foote.

Geophysical Investigations of Uranium Deposits in the Colorado Plateau by R. A. Black.

Underwater Seismic Surveys Applied to Shallow Zone Studies by D. Linehan.

INDUSTRIAL MINERALS

Morning

Mining Geology Session

Geology of Mountain Pass, Calif., Rare Earth Area by D. F. Hewitt.

Operation of Rare Earth Mining at Mountain Pass, Calif. by H. D. Bailey.

Geology of Perlite by Eugene Callaghan.

Geology of Wollastonite by H. M. Butterfield, K. D. Burnham and A. L. Hall.

Ilmenite Deposits of Wyoming by T. A. Hendrickson.

Afternoon

Milling Methods Joint Session with Minerals Beneficiation Div.

A Picture Story of Nevada Silica Sands Including Mining and Milling Operations for the Production of Silica Sand for Glass Manufacturing and Foundry Uses by F. L. Morledge.

A Method for Concentration of North Carolina Spodumene Ores, by Mason K. Banks.

Experimental Production of Feldspar and Silica from Several River Sands in Kansas by Frank W. Bowdish and R. T. Runnels.

Manufacture of Glass and Chemical Sands in the Edwards Paddle Scrubber by Will Mitchell, Jr., T. G. Kirkland and R. C. Edwards.

MINERALS BENEFICIATION

Morning

Concentration

Effects of Alkalinity on the Flotation of Lead Minerals by Marston G. Fleming.

Leach Precipitation Float Process at Anaconda by Fredrick F. Frick.

Sponge Iron at Anaconda by Fredrick F. Frick.

Afternoon

Flotation Theory

Quantitative Bubble Pick-Up Methods by Shiou-Chuan Sun and Ray C. Troxell.

Flotation of Copper Silicate Minerals by Clyde G. DeWitt.

Double Bond Reactivity of Oleic Acid During Flotation by A. M. Gaudin and R. E. Cole.

Analytical Determination of Technical Xanthates by Potentiometric Titration by Carl H. DuRietz.

Afternoon

Agglomeration and Pyrolysis

Operation of Twelve Foot Sintering Machine at Blackwell Zinc Company, Inc.—Blackwell, Okla.

Development of a Continuous Up-Draft Sintering Process by W. R. Burrow.

Pelletizing Southern Hematite Ores by Ballard H. Clemmons.

Testing of Sinter by E. H. Rose.

COAL

Morning

Mine Safety

Prevention of Major Disasters in Coal Mines by J. J. Forbes.

Ventilation and Dust Control in Continuous Mining by F. J. Peternell.

Safety in the Continuous Mining of Coal by W. J. Schuster.

Afternoon

Mining

The Coal Industry in Northern Wyoming and Montana by Walter J. Johnson.

Progress in Degasification of Coal Bearing Strata by Louis A. Turnbull.

Comparison of Mining Potash and Coal by R. R. Knill.

Notes on Mechanized Longwall Mining in Europe by A. J. Barry.

EXTRACTIVE METALLURGY

Morning and Afternoon

Symposium on Copper Smelting

Hurley Furnace and Boiler, Description and Design by E. A. Slover.

Reverberatory Furnace Practice at Noranda by J. N. Anderson.

Modern Smelter Design by J. W. Byrkit.

Reverberatory Furnace Combustion Practice by H. Foard.

Copper Converting Practice at Asarco Plants by F. W. Archibald.

Current Refractory Practice and Development in Copper Smelting by L. A. McGill and W. F. Rochow.

Morning and Afternoon

Titanium and Uncommon Metals

Production of Germanium by A. P. Thompson and J. R. Musgrave.

Rare Earth Separation and Metallurgy at Ames by F. H. Spedding.

Ion Exchange in Wet Process Metallurgy by A. B. Mindler and C. F. Paulson.

Preparation of High Purity Iron at the National Bureau of Standards by G. Moore.

High Vacuum Distillation of Beryllium by C. S. Pearsall.

Thermodynamic Equilibrium for Reactions Involving Titanium Compounds by D. D. Wagman, T. R. Munson and W. H. Evans.

Thermodynamic Properties of Molybdenum Dioxide by N. A. Gokcen.

System Ag_2O-B_2O_3 by H. K. Worner and G. M. Willis.

THURSDAY, FEBRUARY 19

MINING

Morning

Joint Session with Geology Subdivision

Sun Dial Compass by Don Yardley.

A Plea for Mining Geology by Peter Joralemon.

Shore Scleroscope Hardness Tests on Moh's Scale, Minerals from Talc to Quartz, by B. W. Gilbert.

State Geological Surveys and Mineral Industries by Charles F. Deiss.

Hints to the Young Geologist in Surface Examinations by A. F. Banfield.

GEOLOGY

Morning

Joint Session with Industrial Minerals Div.

Geology of the Potash Deposits, Carlsbad, N. Mex. by C. L. Jones.

Some Physical and Chemical Characteristics of Northeastern Oregon Limestone Deposits by L. C. Richards.

Unique Occurrence of Beryl, Sheep Mountain, Utah by N. C. Williams.

Pearl Queen Perlite Deposit of Mineral Mountains, Utah by G. L. Bell and H. E. Schoo.

GEOPHYSICS

Morning

Geochemical Exploration

Recent Developments in Geochemical Prospecting for Minerals by H. E. Hawkes, U.S.G.S.

Geobotanical Methods of Prospecting for Uranium by H. L. Cannon, U.S.G.S.

Methods Used in Geochemical Prospecting Analytical Laboratory by H. Bloom, U.S.G.S.

Oil Prospecting Using a Radioactive Method by Hans Lundberg.

Afternoon

Geochemical (Cont'd)

Copper Soil Anomalies in the Boundary District of British Columbia by W. H. White and T. M. Allen.

Paper by Prof. J. E. Riddell.

Testing for Copper and Zinc in Canadian Glacial Soils by C. T. Bishoff.

Geochemical Prospecting in British Columbia by H. V. Warren.

A Fossil Geochemical Anomaly Near Jerome, Ariz. by L. C. Huff, U.S.G.S.

INDUSTRIAL MINERALS

Morning

Industrial Minerals General

Mining and Use of Drilling Muds in Southern California by John M. Robinson.

New Techniques for Grading Corundum Ores by H. F. Carl, A. Hackman and H. W. Jaffe.

Open Pit Phosphate Mining by C. W. Sweetwood.

Idaho Phosphate and Its Ultimate Use by J. G. Miller.

MINERAL BENEFICIATION

Morning

Mill Design & Construction

Ore Testing to Determine Flowsheet Prior to Plant Design

Feed Preparation and Ore Bedding

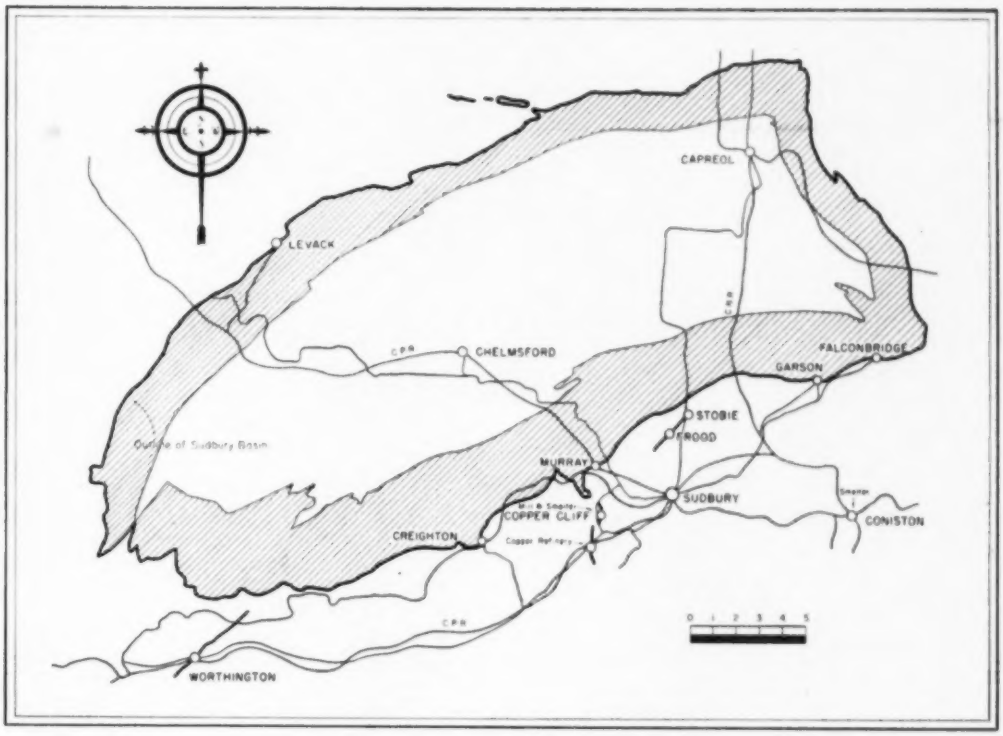
Fundamentals of Mill Design

Methods of Estimating Costs of Plant Construction

Examples of Recent Mill Designs

Afternoon

Clean-up Session



Underground Mining Methods At International Nickel Company

by H. J. Mutz, A. F. Brock, and W. J. Taylor

THE International Nickel Co. of Canada Ltd. operates five underground mines and an open pit. Four of the mines, the Frood-Stobie, Creighton, Murray, and Garson, are on the south range of the Sudbury Basin, map above, within a radius of 10 miles of the city of Sudbury, Ontario. The fifth mine, the Levack, is on the north range of the Sudbury Basin, 30 miles to the northwest of the city. The open pit is operating on surface ores of the Frood-Stobie orebody.

Two pits were opened at the Frood-Stobie mine; the Frood section was started in 1938 and the Stobie section in 1942. To meet the heavy demand for nickel during World War II, open-pit production was accelerated until it constituted over 40 pct of Inco's total tonnage. As a consequence open-pit ore was depleted considerably ahead of schedule; the Stobie pit was completed in the summer of 1951, and it is expected that mining at the Frood pit will be completed in 1953.

The major program launched 10 years ago to develop additional underground production as a replacement of open-pit tonnage thus had to be greatly speeded up. This conversion to all-underground mining will be completed within the next two years, and the underground mines will then have an annual hoisting capacity of 13,000,000 tons.

One of the new mines in the underground expansion program, the Murray, was brought into production in 1950. Ore production from the new Stobie section of the Frood-Stobie mine was commenced on a limited scale in 1951 and will be increased as the program progresses. Delivery of ore to the new Creighton mill was started in the summer of 1951 from the caving project launched at Creighton mine.

When mining was started in the Sudbury district 65 years ago the ore deposits were opened on a small scale and mining methods conformed to a general pattern of small open cast pits, followed by open stopes as mining was extended below the pits. The open stoping methods used were heading-and-bench and shrinkage. In certain cases a type of cut-and-fill mining was used with drywall tramways and drywall chutes in the fill. As the mines were deepened,

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Discussion on this paper, TP 3461A, may be sent (2 copies) to AIME before March 31, 1953. Manuscript, April 14, 1952. New York Meeting, February 1952.

The Transactions papers appearing in Mining Engineering *during 1953 will subsequently appear in AIME Transactions Vol. 196, and may be permanently referenced to that volume.*

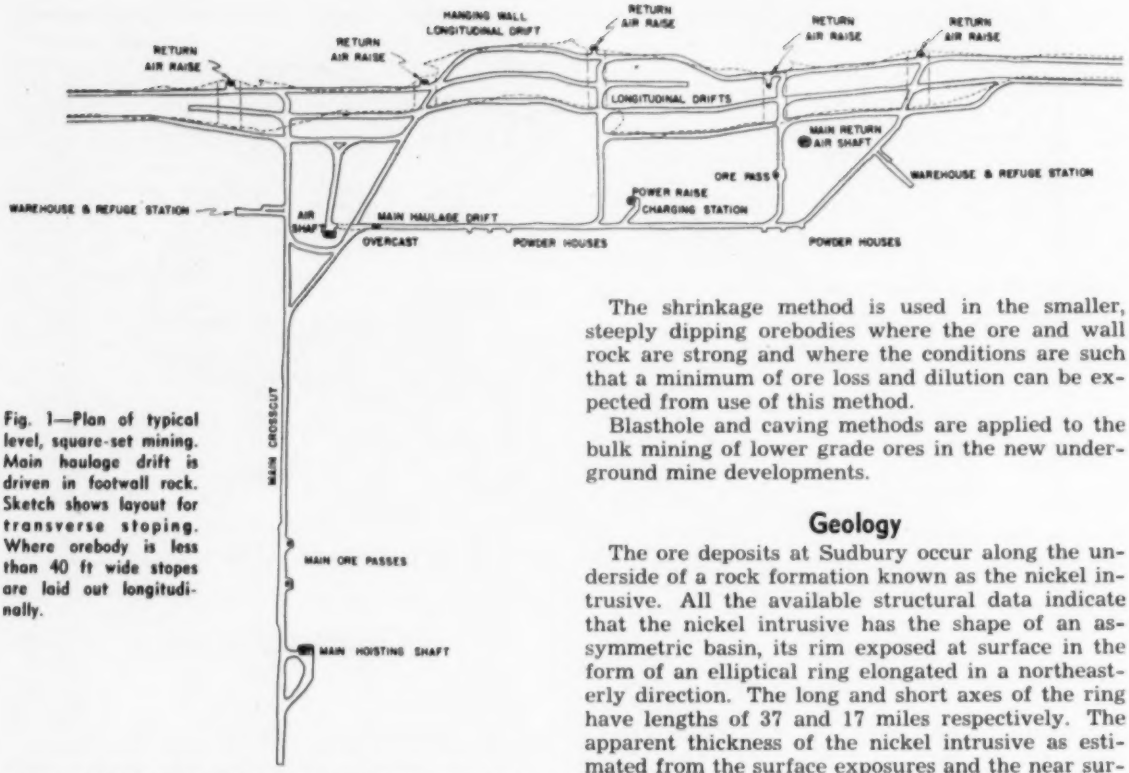


Fig. 1—Plan of typical level, square-set mining. Main haulage drift is driven in footwall rock. Sketch shows layout for transverse stoping. Where orebody is less than 40 ft wide stopes are laid out longitudinally.

a general change to cut-and-fill and square-set mining was effected, and these methods became standard for mining the higher grade ores of the district. With the improvement of metallurgical practice and the development of low-cost bulk mining methods, recovery of the lower grade ores became economically feasible. Blasthole and caving methods are used to mine these low grade ores.

The methods of mining now employed at Inco mines are square-set, cut-and-fill, shrinkage, blasthole, and induced caving. Blasthole and square-set methods are used at Frood-Stobie, square-set and caving at Creighton, blasthole at Murray, shrinkage, cut-and-fill, and square-set at Garson, and blasthole and square-set at the Levack mine.

The choice of stoping methods at each of the mines is determined by conditions peculiar not only to the individual mine, but also to the particular areas and horizons of each mine: the size and shape, attitude, composition, and grade of the orebody; the inherent physical properties of the host rock; the extent to which both the ore and the host rock have been weakened by faulting and movement; the depth below surface; the necessity to minimize subsidence and control rock pressure. In each instance these factors have a bearing on the stoping method which is selected.

Square-set and cut-and-fill methods are used 1—to obtain complete extraction with a minimum of dilution of the higher grade ores and 2—to minimize caving and subsidence of the overlying ground. The square-set method is used where both ore and wall rock are weak, cut-and-fill where the wall rock may be weak but the ore itself strong. The square-set method is also used to recover vertical and horizontal pillars in filled stope areas, as well as to recover remnants of ore left in stopes or in the fringes of orebodies that have been worked by other methods.

The shrinkage method is used in the smaller, steeply dipping orebodies where the ore and wall rock are strong and where the conditions are such that a minimum of ore loss and dilution can be expected from use of this method.

Blasthole and caving methods are applied to the bulk mining of lower grade ores in the new underground mine developments.

Geology

The ore deposits at Sudbury occur along the underside of a rock formation known as the nickel intrusive. All the available structural data indicate that the nickel intrusive has the shape of an assymmetric basin, its rim exposed at surface in the form of an elliptical ring elongated in a northeasterly direction. The long and short axes of the ring have lengths of 37 and 17 miles respectively. The apparent thickness of the nickel intrusive as estimated from the surface exposures and the near surface dips ranges from 1 to 2 miles. It consists of an upper layer of micropegmatite separated by transition rock from a lower, somewhat narrower layer of norite.

The space inside the basin structure is occupied by a series of volcanic and sedimentary rocks, the layering of which outcrops in concentric rings inside those of the nickel intrusive, indicating for this series a basin shape conformable with that of the nickel intrusive. The rocks underlying the intrusive consist, in order of abundance, of gneisses, volcanics, sediments, granite, and breccias.

It appears that an erosional unconformity existed between the rocks that now overlie, and the rocks that now underlie the nickel intrusive, and it is generally accepted, although not proved, that the nickel intrusive was emplaced horizontally between flat-lying rocks above the unconformity, and highly deformed rocks below the unconformity. Differentiation of the nickel intrusive into its component parts, followed by down-warping or infolding, complete the steps by which the basin structure is thought to have been formed. Post-nickel intrusive dikes of granite, trap, and olivine diabase intersect the basin structure, and its continuity is interrupted by faults that displace contacts for distances ranging from a few feet to 2½ miles.

Mining experience of more than 50 years has established the bottom contact of the norite as the primary structure that determined the location of ore deposition. Feeble mineralization along this locus is present for most of its known area, but ore concentrations occur only where the primary locus coincides with essential but secondary structures. The recognized kinds of ore-bearing structure are, first, depressions in the relatively smooth norite footwall in which the norite penetrates the underlying rocks, and second, shearing that roughly coincides with the base of the norite. Either of these

structures is capable of controlling an ore deposit, or both may be present in one deposit; however, it should be noted that although every known orebody is associated with the kind of structures described, there are many such structures in which the mineralization is not of ore grade.

Numerous attempts have been made to explain the obviously close relationship of the ore mineralization to the norite. Their invariable association indicates a common source, and adherence of the ore to the base of the norite has led many geologists to believe that the ores must have accumulated from the nickel intrusive during the process of differentiation. Others have given more weight to the apparently contradictory evidence based on the timing of geological events, and have proposed that the ores were introduced hydrothermally after the nickel intrusive was frozen and deformed. The balance of evidence favors the first explanation, but in the final analysis it may prove that neither explanation is wholly correct.

The ores are mined primarily for nickel and copper, but there is also important production of cobalt and of the platinum group metals, as well as gold, silver, selenium, and tellurium. The principal ore minerals are pyrrhotite, pentlandite, and chalcopyrite; pyrite and the arsenides of nickel, cobalt, and platinum are the notable accessory minerals. The typical orebody lies astride the norite contact and consists of varying proportions of disseminated ore, breccia ore, and stringer ore. Most of the sulphide on the norite side of the contact occurs in the disseminated form, whereas the sulphide below the norite contact is massive, although it always contains some associated rock; it is named *breccia* ore or *stringer* ore, depending on whether the sulphide or the rock is the continuous component.

Levack mine is located on the flatter northwest side, and the other four mines on the steeper southeast side of the assymetric basin. Levack, Murray, and Frood-Stobie are examples of deposits where the secondary structural control consists of depressions in the base of the norite, or they might be described as places where the norite has made unusual penetrations into the footwall rocks. At Levack and Murray the penetrations take the form of blunt embayments or troughs with long dimensions running down an approximate 40° dip at right angles to the norite contact. The Murray orebody is a single mining unit. The Levack mine consists of a group of orebodies separated by nonmineable mineralization along the strike and overlapping each other in depth range.

The Frood-Stobie mine is a special example of ore control by a depression in the norite footwall. In this instance the norite penetration of the underlying rocks, instead of being blunt, is sharp and very deep. It has the shape of a dike-like appendage projecting downward from the bottom of the norite. Erosion has removed the horizons at which continuity once existed between the appendage and the main body of norite, so that the Frood-Stobie orebody occurs in a pocket of norite now isolated in the basement rocks about a mile from the parent body. At the surface elevation this remnant has an overall length of 9600 ft. In vertical cross section it wedges out downward along a 75° dip and bottoms, for the length so far explored, at about 4000 ft. All the norite in the remnant carries disseminated sulphides, and although the intensity varies widely, most of the norite is mineable; in addition, there is a large, but by comparison, minor volume of breccia and stringer ore located along the bottom of the deepest parts of the disseminated unit.

The essential secondary structure at Garson is shearing that coincides approximately with the norite contact. The dominant shearing strikes east-west and dips at about 75° to the south, away from the center of the basin. A number of subsidiary shears striking east-west and dipping about 55° to the south diverge upward from the parent structure from successively deeper horizons and terminate in the norite. In vertical cross section the norite contact traces an irregular course across each of the successively deeper wedges of ground lying between the main shear and its flatter branches. The ore occurs along the main and tributary shears and along the norite contact between them; hence the overall mining pattern is complex. Mineable widths vary from several feet in the vein-like deposits of ore along the shears up to a maximum of about 200 ft where swells of ore occur in the zones of shear convergence.

The structural control for the Creighton ore consists of both shearing and a depression in the norite footwall. At surface the embayment formed by the depression is about a mile long and half a mile deep; it plunges at 45° to the northwest. A northwest dipping shear strikes into the depression from the northeast and there develops a branching pattern so oriented that it coincides with the plunge of the depression. The various branches of the shear cut across the southeast side of the depression where they diverge downward and southeastward. Consequently each branch, along both the strike and the dip, passes from norite into the footwall rocks and causes displacements of the norite contact ranging up to several hundreds of feet.

The mineralized zone has the shape of an irregular but continuous pipe lying along the plunging structure just described. Most of the zone consists of norite containing disseminated sulphides, the

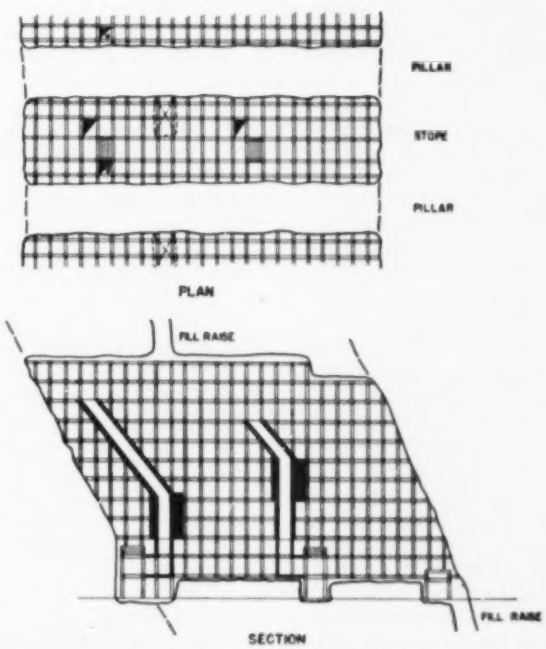


Fig. 2—Plan and section of square-set stope.

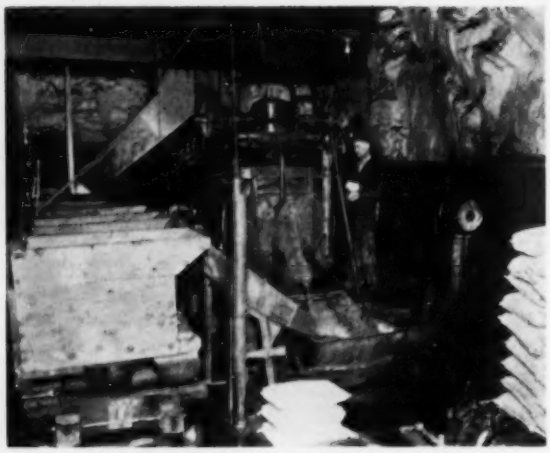


Fig. 3—Concrete mixing station.

minor portion being breccia and stringer ore located in large and small pockets on the underside of the mineralized norite and in sheets along the shears. In a general way the intensity of the disseminated mineralization decreases upward from the base of the norite, but heavier than normal disseminations occur adjacent to the sheets of breccia ore that lie along the shears.

The early mining, dependent on direct smelting ores, was confined to the breccia ore deposits. In more recent years the introduction of milling and the development of suitable mining methods have permitted the mining of an ever-increasing proportion of the disseminated norite.

Stoping Methods

Square Set

General Layout: Narrow square-set stopes and pillars have been found the most satisfactory from the standpoint of safety and ground control, and a system of transverse stopes 30½ ft wide with 19-ft rib pillars is used where an orebody is more than 40 ft from footwall to hanging wall. In areas where an orebody is less than 40 ft wide the stopes are laid out longitudinally; the length of a standard longitudinal stope is equivalent to the width of two standard transverse stopes and one pillar. The pillars in longitudinal stoping areas are the same width as those between the transverse stopes.

The level development, see Fig. 1, for transverse square-set stoping consists of a main haulage drift in the footwall rock, one or more 11x11-ft longitudinal extraction drifts, and an 11x11-ft longitudinal return air and supply drift for the stopes being mined on the level below.

The extraction drifts are in ore and the number driven is governed by the width of the orebody. The first is driven on the footwall contact, and where more than one is required the others are parallel to it at approximately 50-ft intervals. The return air and supply drift is also in ore, close to the hanging wall. Crosscuts at 500-ft intervals connect the footwall drift with the drifts in the orebody.

In normal ground extraction drifts are timbered as they are driven, with temporary caps and lagging for back support, and slashed later to a height of 18 ft to make room for permanent gangway timber.

The permanent gangways are two sets high. The sets are 5½x8½ ft center to center of posts, and the clear width inside the gangway is 7 ft 8 in. The clearance above the base of rail in the lower sets is 7 ft 5 in., and the inside height of the upper sets is 6 ft 6 in. As the upper gangway sets are erected they are lagged with 8-in. flatted timber. The lagging is supported on false caps over the gangway caps and separated from them by squeeze blocks. The permanent gangway covering is put on after the sill has been cut in the stope above.

Where the extraction drifts cannot be opened to full height without more support than is afforded by the temporary back timber, they are timbered as they are driven with lower floor gangway sets. The back slash to make room for the second floor sets is broken down on 8-in. lagging placed on the sets before blasting.

The return air drifts are timbered with lower floor gangway sets, and 3-in plank is used for back lagging over the sets. Entrance to the stope manways is from the extraction drifts, and the rounds for the manway bases are driven in the drift wall before standing the permanent timber.

All square-set stopes are silled 9 ft above the base of rail of the level and are mined to within 50 ft of the level above, leaving a 59-ft crown pillar

Fig. 4—Lever-operated gangway chute.

that is not recovered until the pillars above it have been mined out.

A 7x11-ft cribbed stope raise to serve as a manway, airway, pipeway, and supplyway into the stope is driven from the back of the sill floor to the hanging wall longitudinal drift on the level above. The raise is collared midway between the footwall and hanging wall and adjoining the pillar on the side of the stope opposite the manway. Vertical raises are preferred, but they may be driven at any inclination down to 55°.

Stope Timbering: Originally all stopes were timbered with sets 5½ ft square, and five sets were used to span from pillar to pillar in a standard transverse stope. This is still the practice in unusually heavy ground. In normal ground present practice is to use four sets to span the stope, a 5½-ft square set against each pillar with two 8¼x5½-ft sets between.

The sets used in stopes are framed in the mine shops from local pine timber cut to exact length at the mills and flatted on two sides to 8 in. thick.

The use of concrete in constructing chutes has made it possible to handle all the ore broken in a transverse stope up to 100 ft long, or approximately 50,000 tons, through one chute.

In the four-set stopes the chute and a wing from one side of the chute open into adjoining sets in the two center rows. In five-set stopes the chute is in a set in the center row and has wings from two sides into each of the adjoining sets in the rows on each side of the center.

With only one chute in a stope the chute is spaced about halfway between the hanging wall and footwall to give a slushing distance of not more than 50 ft. The chute is inclined parallel to the dip of the footwall to maintain its position in relation to the footwall on succeeding floors as the stope is mined.

Two or more chutes, see Fig. 2, are required in stopes where the orebody is wider than 100 ft. One of the chutes is kept 15 ft from the footwall and the others are spaced from it at approximately 50-ft centers. Normally the chutes are carried up directly from the gangway in the longitudinal drifts, but where an extreme flattening of the footwall occurs close to the haulage level, boxholes up to 60 ft long may be driven in waste rock to the required position of the footwall chute in the stope.

One manway only is carried up from the level in each stope. The manway is in the row of sets next to a pillar, and when the stope has been mined out the manway is connected at the top to the stope raise for subsequent use as a service opening to the adjoining rib pillar.

The stope ore chutes open into the upper gangway sets in the longitudinal haulage drifts and from there to the top of the second floor of the stope the chutes are constructed of timber. From the second floor to within four floors of the top of the stope they are concrete. The timbered portion of the chute is 5 ft square inside, and the walls are built up of heavy salvage timbers not less than 3 ft in length packed end-on to the inside face of the chute to form solid panels. The timbers forming the panel are spiked together as they are laid, and the panels are secured by wedging against the stope square sets. Timber is used for this construction in preference to concrete because it is more resistant than concrete to blasting.

The concrete portion of the chute is built up through the square sets and is poured in 7-ft vertical lifts corresponding to the standard square-set height. To allow the use of chute wings the top of the chute is kept one set below the mucking floor and each new lift is poured before filling is started on the floor above.

In the construction of concrete chutes the outside forms are made of 1-in. rough lumber nailed to the square set timbers. Inside forms are prefabricated and consist of an angle iron frame and rectangular panels made of 1¼-in. dressed fir. The forms are supported on a chute platform held in position with four 1¾-in. diam pins placed in 2-in. pipe sleeves set in the top of the previous pour. Wedges driven into the corners between the panels hold them securely against the angle iron frame.

The concrete portion of the chute is 4½ ft square inside. The walls are 14 in. thick in the vertical portion; in the inclined portion the bottom is 18 in. thick, the side walls 15 in. thick, and the top 14 in. thick. Where a change in inclination from the vertical to an incline is made, the hanging wall and footwall sides of the vertical portion are strengthened by increasing the thickness of the concrete for 14 ft below the point of change.

Concrete is mixed at a central mixing station, see Fig. 3, and is delivered to the stope from the level above through a salvage wood-stave pipeline in the stope raise. The aggregate used is pit gravel with boulders more than 3 in. in diam screened out, and the mix contains one part cement to five parts gravel with a dispersing agent added to reduce segregation during transport.

Description of Mining Cycle

Stoping: Stope silling is begun by driving a 10x10-ft pilot drift 9 ft above the base of rail on the longitudinal center line of the stope from one of the longitudinal extraction drifts to the stope limits at the hanging wall and footwall. Subsequent widening from the pilot drift to the pillar walls is done by diamond-drill blastholing. A diamond drill is set up on the second floor of the gangway in an extraction drift, and blastholes are drilled parallel to the pilot drift to break a slice 3½ ft thick extending

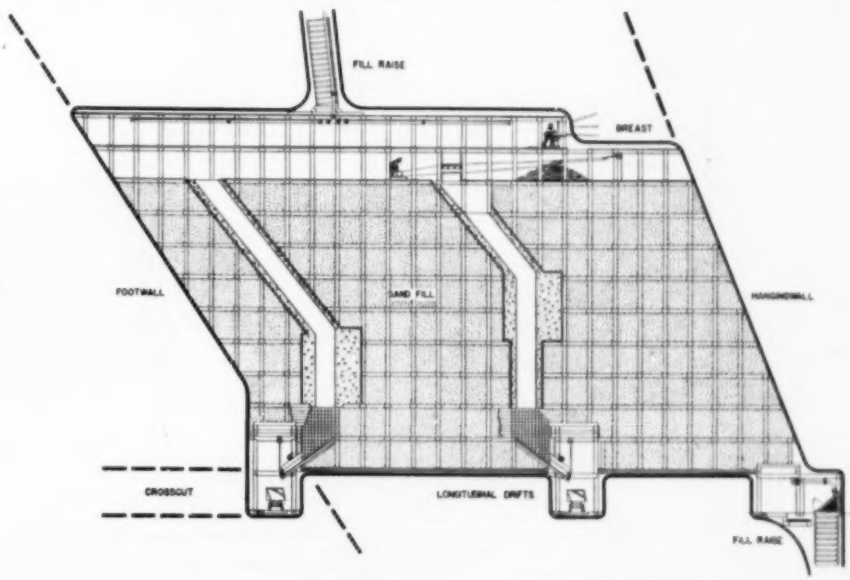


Fig. 5 — Section through a standard square-set stope, which is mined overhand in a series of 7-ft high horizontal slices. New slices are started at the stope raise. A slot two sets wide is opened across full stope width. From the slot the floor advances first to hanging wall, then to footwall in a series of blasts equivalent to a complete row of sets.

Fig. 6—Unloading tracks at Frood-Stobie sand plant.

from one extraction drift to the next, an approximate length of 50 ft. Four blastholes, at 3-ft centers vertically, are drilled for each slice. They are column-loaded with 1¼x8-in. sticks of 75 pct gelatin dynamite and are detonated with delay electric blasting caps. Three successive slices are blasted, and the broken ore from each slice is removed before the succeeding slice is blasted. Widening in the first block selected is completed, and if necessary this portion of the stope is timbered, before widening on the opposite side. Adjoining blocks are widened in a similar manner until the stope is completely silled. The ore broken on the sill is removed by slushing into cars in the extraction drifts with 15-hp double-drum, air-operated slusher hoists and 42-in. scrapers.

In heavy ground power-feed drifters are used instead of diamond drills, and 10½-ft holes at 2½-ft centers are drilled to break a 10x10-ft slash into the pilot drift. The broken ore from each slash is removed immediately and the open ground is timbered before further drilling is done.

The stope fill raise is started when silling has been finished around the raise location. An area 3 sets square is mined on the second floor and the raise is collared in two of these sets. It is driven to the level above while the remainder of the stope is being silled and the second cut is being mined. A slide is built from the raise to the nearest extraction drift to allow the broken ore from the raise to be loaded directly into cars.

Sill floor timbering is started at the extraction drift gangway and the caps and girts of the sill square sets are placed to match those of the second gangway sets. The sill sets stand on the solid floor of the stope; the post length varies with the level of the floor and on this account the posts are supplied overlength, framed on one end only, and are trimmed in the stope to the proper length.

Mining the second floor of the stope follows the completion of silling. After the broken ore from the second cut has been removed the sill is prepared for filling; extraction drift gangways are sheeted and lagged, loading chutes, see Fig. 4, are built and equipped with lever-operated control gates, chutes are raised from the second floor of the gangway to the top of the sill sets, and the permanent sill floor is laid and pillar fences are built. The floor consists of 5-in. flatted 11-ft sills placed lengthwise of the stope at 5½-ft centers and covered with two layers of 2 in. x 11 ft plank. The plank in the upper layer is placed at right angles to that in the lower layer, and joints between planks in both layers are staggered. For the pillar fence 2 in. x 11 ft plank or 11-ft edged slabs are nailed to the inside face of the square set posts along each pillar wall. Joints between planks of adjoining rows are made on alternate posts. The extraction drift gangways are sheeted with 8x10-in. timbers 9 ft 4 in. long laid on two 10x12-in. longitudinal stringers, one above each line of gangway posts, and supported on and separated from the gangway sets by 6x10-in.

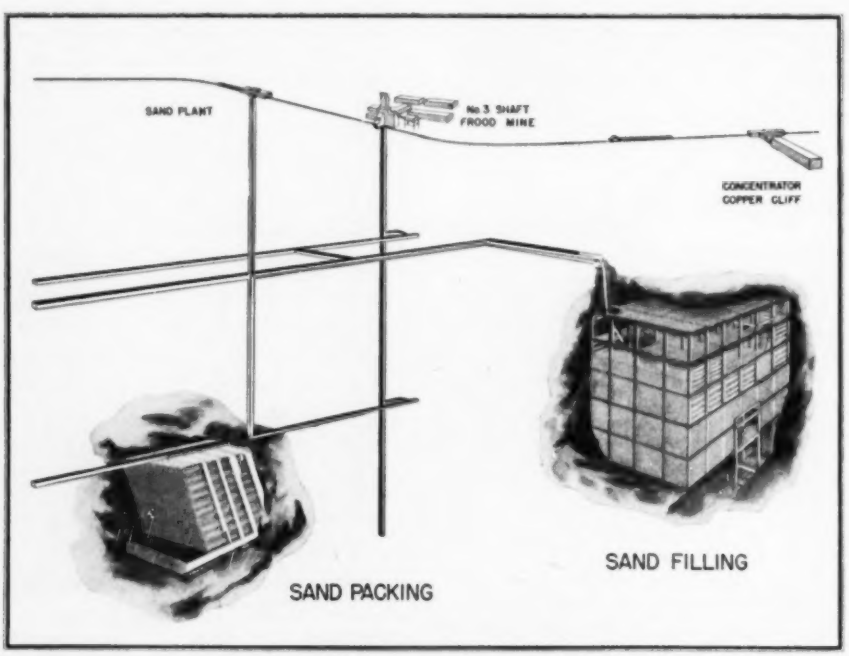


Fig. 7—Diagrammatic sand fill flowsheet.

Fig. 8—Pouring sand fill in square-set stope.

squeeze blocks 15-in. long placed over the posts. The sides of the gangway are lagged by nailing plank to false posts separated from the gangway timber by 8-in. spacer blocks.

In a stope to be filled with water-borne sand, all openings from the drifts into the stope are sealed with a single layer of burlap which is extended 2 ft away from the sides of the gangway into the stope before being cemented to the floor and walls.

A stope, shown in Fig. 5, is mined overhand in a succession of horizontal slices each 7 ft high. Normally each new slice is started at the stope raise. Before starting the cut, standard practice is to pin the raise cribbing to the solid 7 ft above the back of the stope, cut an opening through the side of the crib 21 ft above the back, block the chute compartment at this point with a platform supported on booms, and then remove the cribbing from the bottom 7 ft of the raise and widen this portion to make room for two sets of timber. Two more sets are broken to form a slot two sets wide that is then opened across the full width of the stope. From this slot the mining floor is advanced first to the hanging wall and then to the footwall in a series of blasts each equivalent to one complete row of sets.

Drilling in the stopes is done with power-feed drifters on 24-in. sliding cone shells using 1-in. quarter-octagon drill rods with detachable bits. Standard column bars are 5½ ft long and column arms are 5-ft lengths of 3-in. extra heavy pipe with universal clamps and 5-in. cone dumps.

The number of holes required to break a breast 30½ ft wide varies between 30 and 40. Holes are 6 ft deep and drilled in three rows. In the upper row the holes are collared below the girts and are inclined upwards at 15°; the pillar holes in each row are collared inside the posts and are drilled outward at 15°.

The standard explosive for blasting in stopes is 70 pct semi-gelatin dynamite, and the normal charge is three to four sticks per hole. Each stick of explosive is tamped separately, and the holes are stemmed with 1¼x8-in. sticks of clay stemming. The holes are detonated with No. 6 blasting caps and tape fuse supplied in 10-ft lengths and trimmed to give the proper firing order.

Before the blast is fired, lagging under the breast and the front half of the mining floor sets next the breast is removed. The sets are well braced with angle braces and all exposed members of sets beneath the breast are covered with bulkhead timber.

After each breast has been blasted the back and breast are washed, inspected for missed or cut-off holes, and scaled from under cover of the last row of sets. The area adjacent to the blast is cleaned up, and broken or dislodged timber is replaced. The booms are then advanced, blocked, and covered to give protection to the men working near the breast on the mining floor and on the slushing floor below. Slushing is started as soon as it is safe to do so, and when enough ore has been removed to make room for timber the timbermen stand the new line of sets. The set timbers are fastened together as they are erected and when the row has been completed are blocked to the pillar with 8-in. flatted timber and to the breast with 5-in. timber.

Blocking on the booms is caught up on the sets by placing a 3-in. plank and a 7-in. bulkhead timber over each cap and then wedging between this timber and the cross blocking on the booms until the booms are freed. Booms are not taken down but

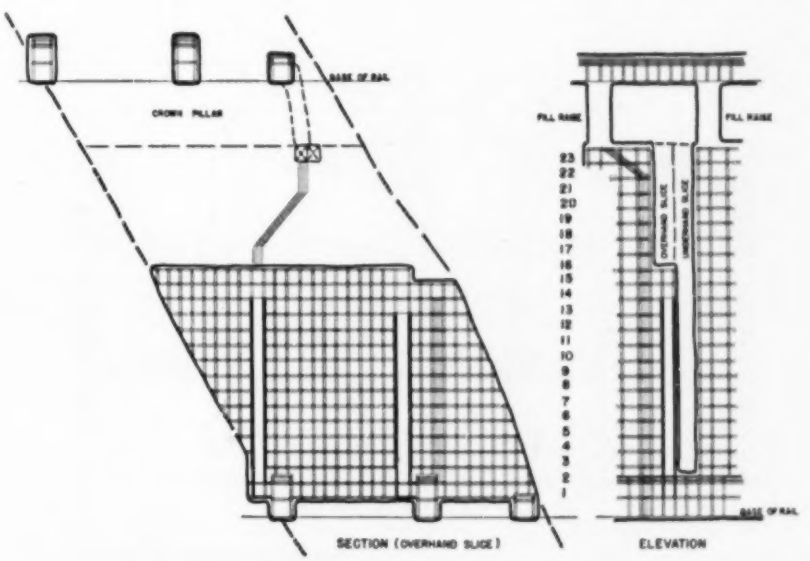


Fig. 9 — Plan and section of overhand slice in square-set pillar. Slice is mined in series of 7-ft horizontal floors started at the fill pass manway by opening a slot. From this slot stoping advances to the limits of the orebody in a series of breasts one set long and two sets wide.

Fig. 10—Concrete floor in cut-and-fill stope.

Fig. 12—Air-leg drill in cut-and-fill stope.

are left in place ready to be moved after the next blast. Each set is lagged with 5-ft slabs.

For handling the broken ore in the modified 4-set stopes 15-hp double-drum air-operated slushers and 42-in. scrapers are standard equipment; 7½-hp double-drum slushers are used in 5-set stopes. In the 4-set stopes the ore is slushed in the two center rows of wide sets into the chute or wing. The floor in the slusherways is 60-lb rail at 15½-in. centers; along each pillar wall the sets are floored with 2-in. plank. Slides of 5-in. flatted timber built beneath the breast in the two outer rows of sets deflect the broken ore into the slusherways and also serve as travelways under the breast.

Chute openings are guarded by a grizzly of 60-lb. rails at 15½-in. spacing raised 2 ft above the floor of the stope. Ore is scraped into the chute through the end opening between the floor and the grizzly and pieces too large to go through this opening are blockholed.

Filling

The most recent and significant development in the square-set method of stoping at Inco has been the use of water-borne sand at Frood-Stobie and Creighton for sand filling current square-set stopes and for sand packing the older waste-filled stopes to consolidate the fill and stabilize the ground left in pillars.

The screen analysis of the fill sand is:

Mesh	Pct
+ 65	12
− 65 and +200	60
−200 and +800	25
−800	3

Sand for Frood-Stobie, recovered from tailing at the concentrator in Copper Cliff, is dewatered and shipped to the mine in railway cars.

At the mine the sand is dumped into concrete receiving bins, see Fig. 6, and repulped for use underground to a density of 60 to 65 pct solids by hydraulic monitors supplied with recirculated mine water at 100 psi. The pulp is flushed from the bins into a rake agitator and is drawn from the agitator tank into a distributor box with connections to three sand pipelines that enter the mine through a

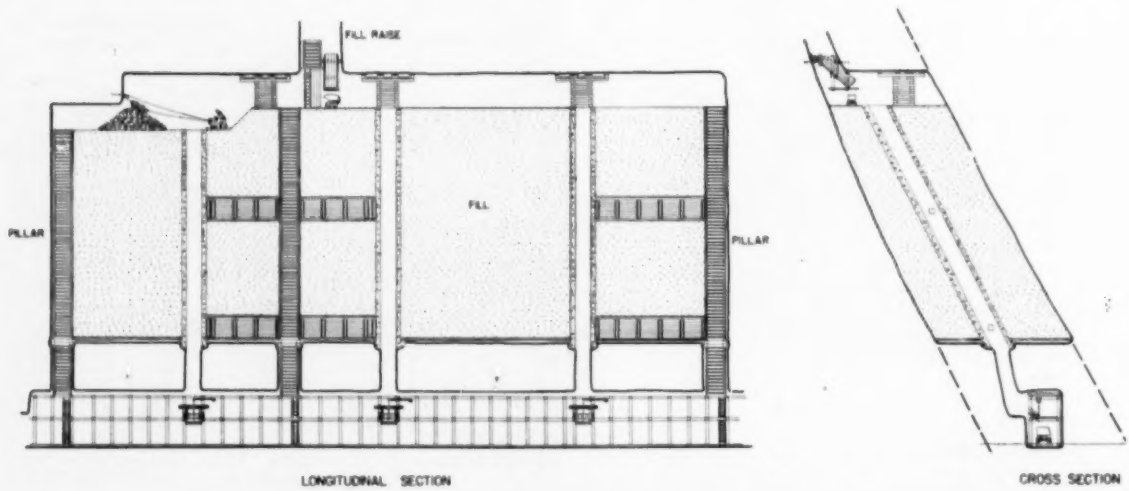


Fig. 11—Sections of a longitudinal cut-and-fill stope.

Fig. 13—A 15-hp slusher in cut-and-fill stope.

service raise extending from 3100 level to surface. A diagram of the method of distribution is shown in Fig. 7. The pipe used for the sand mains through the service raise and the main haulage drifts on the levels down to 1800 level is 6-in. standard weight rubber-lined pipe with 400-lb loose flanges, and from the 1800 to the 3100 ft levels is 6-in. extra heavy rubber-lined pipe with 600-lb loose flanges.

Distribution lines on the levels from the mains to the stope raises are of unlined 4-in. extra heavy pipe, with 400-lb flanges to within 1500 ft of the end of each distribution line and 150-lb flanges for the rest of the line.

No valves are used; each line from surface serves one level at a time and the connection from a main in the service raise to the level line is made by removing one length of straight pipe from the main and connecting in a bend to join the two lines. Connections from the 4-in. pipelines on the levels to the lines in the stope raises are made with lengths of 4-in. wire-wound hose with flanges of hard rubber connected to the pipelines by split steel flanges.

An independent telephone system provides direct communication between the working place under-

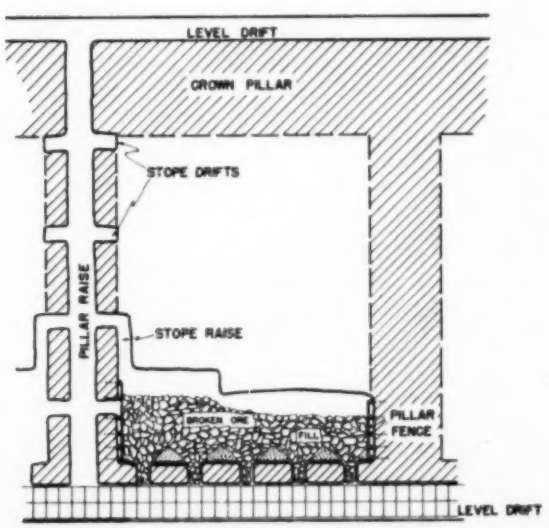


Fig. 14—Section of longitudinal shrinkage stope.

BLAST HOLE STOPING

Fig. 15—Sublevel blasthole layout, Frood-Stobie No. 7.

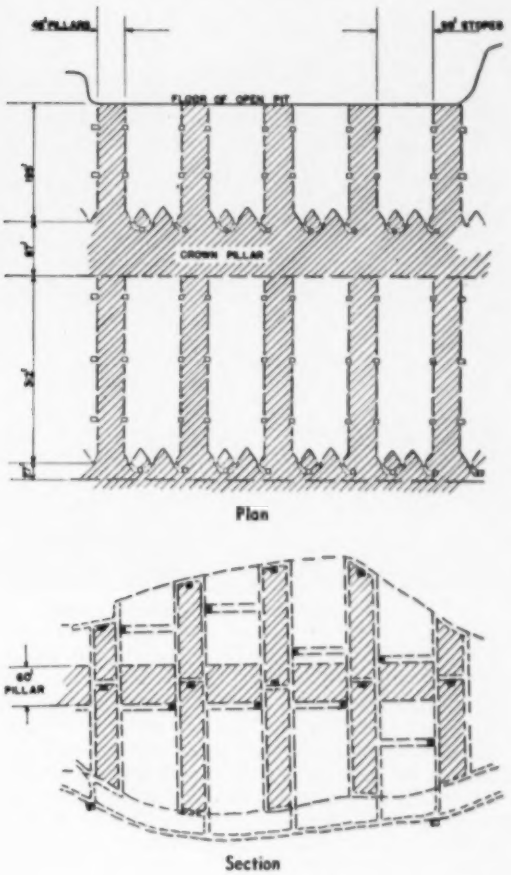


Fig. 16—Sublevel blasthole stoping layout, Frood-Stobie No. 3.

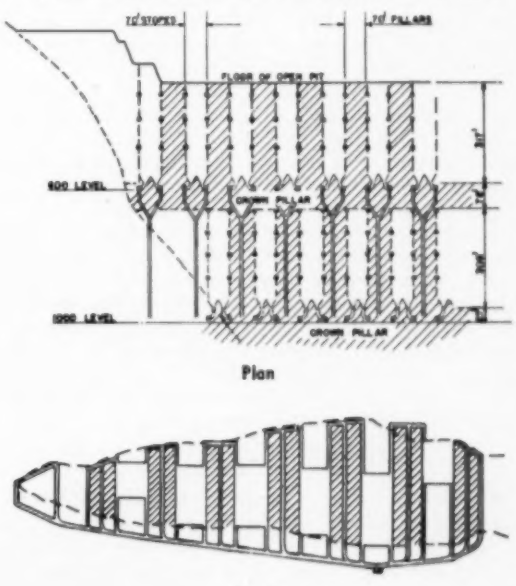


Fig. 17—Blasthole stope breaks through to open pit.

ground and the sand fill plant at surface for control of sand delivery.

Sand for filling at Creighton is recovered from tailing at the new Creighton concentrator. The tailing is deslimed and the sand is piped underground. The distance the sand is piped to reach stopes on the deepest level totals 9500 ft; more than half this distance is horizontal.

In preparation for filling, the manway and the concrete chutes are raised one floor, and repairs are made to the chutes if required. Rails in the bottom of the slusherways, floor plank, and grizzly rails are all taken up and installed on the floor above. Pillar fences on the slushing floor are completed and the manway set, the set over each concrete chute, and the chute wings are enclosed with burlap.

Panels of horizontally slotted 2-in. plank are built into one of the chutes to allow the water to run off from the sand fill. The water decants through the openings in the panels and drains through the chute to the level ditches.

Fill pours, see Fig. 8, are made alternately on the hanging wall and footwall sides of the decant chute, starting at the stope limits and working toward the chute. Each pour is controlled to produce a slope down to the decant point, and when the sand has risen in the stope to the point where it begins to run through the decant panel opening in use, that opening is closed and the water decants through the opening next above it. The average rate of placing sand fill in a stope is 250 tons per hr.

Square-Set Pillar Mining

Rib Pillars: The four-set transverse pillars in waste or gravel-filled stoping areas are recovered by a combination of overhand and underhand stoping methods. The pillars are each divided into two equal longitudinal slices. The first slice is mined by standard overhand square-set stoping and the second by underhand stoping. Recovery is started in alternate pillars and each is mined out before work is started in either of the adjoining pillars. The overhand slice is normally stoped the full length and height of the pillar, while the underhand slice is divided into four tiers of stoping blocks, each block five to six sets long and six to eight sets deep.

When the overhand slice has been stoped out and filled, stoping is begun in the upper hanging wall block of the underhand slice and blocks against the hanging wall are mined in succession from the top to the bottom of the slice. This order of mining is repeated in each succeeding vertical row of blocks working toward the footwall until the underhand slice has been completely mined.

The method of silling the overhand slice in a pillar stope is the same as the method of silling with drifters in a regular square-set stope except that no pilot drift is required. Beginning at one of the extraction drifts the sill breasts are slashed to the free face of the pillar and the broken ore is slushed to cars in the extraction drift. The slushing equipment used for this work is a 7½-hp double-drum, air-operated slusher hoist with 36-in. scraper, standard for all pillar slushing.

The overhand slice is timbered with standard square sets, matched to those in the adjoining stopes to make the best possible fit for the spreaders used in the underhand slice. Before the first fill is placed in the overhand stope a standard sill floor is laid, chutes are established, the gangway in the extraction drift is sheeted and lagged, and the pillar fence is built as in the regular square-set stopes.

The overhand slice, see Fig. 9, is mined in a series of 7-ft horizontal floors. Each floor is opened at the fill pass manway by the mining of a slot 1 set wide from the manway across the width of the slice, and stoping is advanced from this slot to the limits of the orebody in a series of breasts 1 set long and 2 sets wide.

Drilling, blasting, slushing, timbering, and filling practices are the same in overhand pillar stopes as in regular square-set stopes.

In the underhand slice the upper stoping blocks are opened from the travelway under the crown pillar, and stoping is started at the chute. The block is mined as an underhand rill inclined at 52°. Each new floor is opened at the chute and the ore

Fig. 18—Section through panel of blasthole stopes, Murray mine.

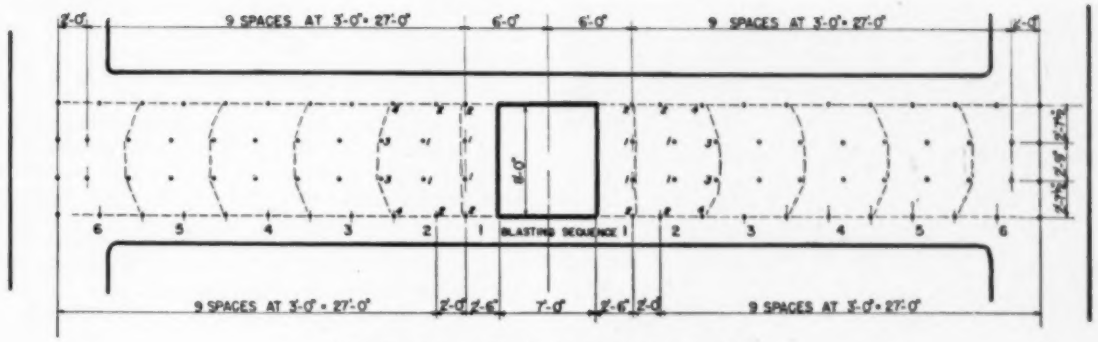


Fig. 19—Pattern of blastholes for opening stope slot.

is stoped down the rill in a succession of benches. Bench drilling is done with 55-lb pluggers, detachable bits, and drill rods up to a maximum of 7 ft long. Top floor widening is done with drifters.

The underhand stoping blocks are timbered with spreaders to keep the fences on each side from collapsing, and the spreaders are reinforced with A-braces on the two top floors of each block where the stope timber must also support either the ground in the crown pillar or the floor of a block that has been filled.

The spreaders against the ground and those that support the fill floors are 10x10-in. fir; the rest of the spreaders and the A-braces are 8-in. flatted pine. All spreaders are 11 to 13 ft long with plain ends. They are spaced 5½ ft apart horizontally and 7 ft vertically and are supported at each end on the pillar fence posts. Corresponding joints in the posts on each side of the underhand stope are cut out to provide a 4-in. bearing for the spreaders, and 3-in. plank cleats are nailed to the face of the posts for added bearing where required.

As the top floor is opened the back spreaders of 10x10-in. fir are put in place under the crown pillar. They are blocked to the ground with 8-in. bulkhead timber and are lagged with 3-in. plank. As in all stopes, ground above the spreaders is supported on booms while the spreader is being erected. The spreaders in the rows below are installed and A-braces erected as soon as room is made for them. A floor of 3-in. plank is laid from spreader to spreader at each 7-ft elevation, the floor plank secured by nailing to the spreaders.

The underhand slice of a pillar has usually been crushed to such an extent that much of it is loose which can be removed by barring. Before drilling is started on a bench all the loose is barred off and the bench is carefully examined for missed or cut-off holes. Standard practice calls for holes drilled vertically to a depth of 7 ft, but on account of the fractured ground many cannot be drilled to the desired depth and the average depth is nearer 5 ft. Holes are loaded for blasting according to the standard practice in regular stopes. Powder averages three sticks per hole. Each blast is limited to the number of holes required to make room for one spreader.

Except for the last four floors at the bottom of each stoping block the ore in the underhand pillar stopes runs down the rill into the chute as it is broken. When the rill on these floors is being levelled the broken ore is slushed to the chute with a slusher set up on the bottom floor.

To prepare a block for filling, the chutes and manways beside the block and the chute and manway to be left open in the block are lagged with 2-in. slabs. A fence of 2-in. slabs is built from top to bottom of the block on the second vertical line of spreaders one set from the footwall side, leaving a vertical row of sets open to be converted into a chute and manway for the next block. In the bottom row of blocks a sill floor is laid at the same elevation as the sill floor in the stopes on each side.

In stopes to be filled with waste rock or gravel, no further preparation is required before placing the fill, which is transferred from the stope fill raise either directly by slides or by tramming. For the top blocks the fill is dumped from the travelway at the top of the overhand slice, and for the lower blocks it is passed through slides or is trammed to the ore chutes and diverted into the blocks by bulkheads in the chutes. Floor plank, spreaders, and A-braces are recovered as filling progresses. Top floor openings, no longer required, are back-filled.

Underhand slices to be filled with water-borne sand are divided into blocks the same as those to be filled with waste rock.

When the overhand slice has been stoped out and filled, stoping is started in the bottom hanging wall

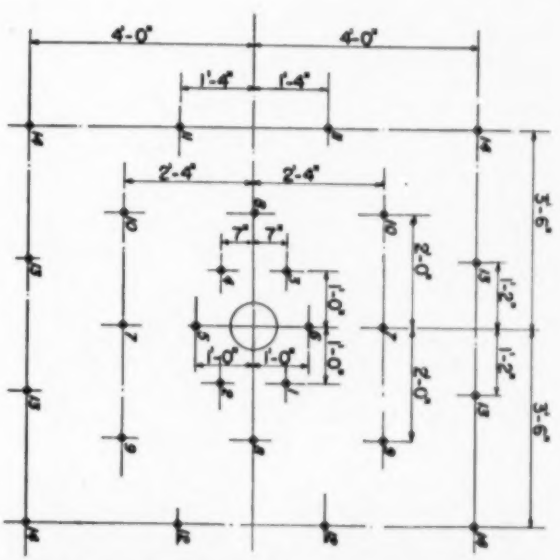


Fig. 20—Drill hole pattern in diamond drill slot raise.

Fig. 21—Stope slot opened by churn drilling.

block of the underhand slice and the blocks against the hanging wall are mined in succession from the bottom to the top of the pillar. This sequence of mining is repeated in each succeeding vertical row of blocks working toward the footwall. When the bottom block of each row has been mined, a standard sill floor is laid, the set to be kept open is lagged, and the block is filled to the back. For the middle and top blocks all that is necessary before filling is to lag the sets to be kept open for mining the adjoining block.

Mining Pillars in Sand Filled Stoping Areas

Rib Pillars: Recovering four-set pillars between stopes that have been sand filled or sand packed is a much simpler operation than mining those between waste-filled stopes. Sand filling and sand packing the stopes has been found to stabilize the remaining ground to such an extent that the pillars can be mined overhand in the same manner as ordinary stopes. Starting from the extraction drift gangways, the sill and second floor in the pillar are stoped out over the full pillar area, the sill is filled, and standard 7-ft horizontal floors are stoped from the pillar in regular succession.

Standard concrete chutes are used, following the same general layout as in ordinary stopes. Sand filling also is done in the same way as in ordinary stopes, and the preparations for filling are the same except that no fences are required, since the pillar stope fill is contained by the sand in the stopes on each side and the wall rocks at each end of the pillar stope.

Crown Pillars: Crown pillars are mined overhand in three-set transverse slices that are mined in three groups, the working stopes in each group being separated by two dormant stopes. A slice may be mined as one stope, or in wide sections of the orebody it may be divided into two or more stopes. In heavy ground the stope length may be as little as four sets.

Broken ore from the first two floors of a stope in the crown pillar is slushed over the fill in the stope below the crown into the boxhole. The slusher hoist is set up in a station cut in rock on the footwall side of the boxhole. When the first two floors have been stoped out a chute is timbered from the boxhole to the top of the first floor and the floor is filled. Broken ore from the remaining two floors is slushed over the first floor fill into the chute. On the sublevel the broken ore is slushed from the boxholes to the ore pass raise with a 15-hp slusher hoist and 42-in. scraper.

For filling stopes in crown and floor pillars sand pipelines are brought down into the floor pillar from the level above or up from the level below, whichever happens to be the most convenient; in crown pillar stopes the sand pipelines are always brought in from the level above. Before filling is started the pillar fence and gangway lagging is covered with burlap and arrangements are made to decant the water into an open set or a chute. No sill floor is laid in crown or floor pillar stopes. In filling the first floor of a stope the sand is allowed to permeate the fill below the floor pillar, further to stabilize the ground in the immediate area.

At mines where sand fill is not available and waste rock or gravel is used for filling stopes, the crown pillars and floor pillars are mined in a combination of alternate two-set overhand and underhand slices. Fill for floor pillars is supplied from the level above through raises in the footwall and is trammed to the stopes in 16 cu ft end-dump cars.

Cut-and-Fill

Transverse and longitudinal cut-and-fill stoping methods are both used at Inco, the choice between

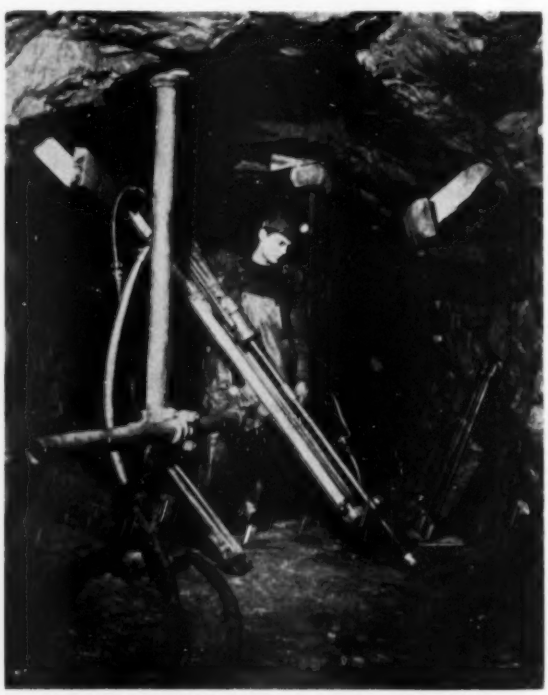


Fig. 22—Blasthole drilling with tungsten carbide bits.

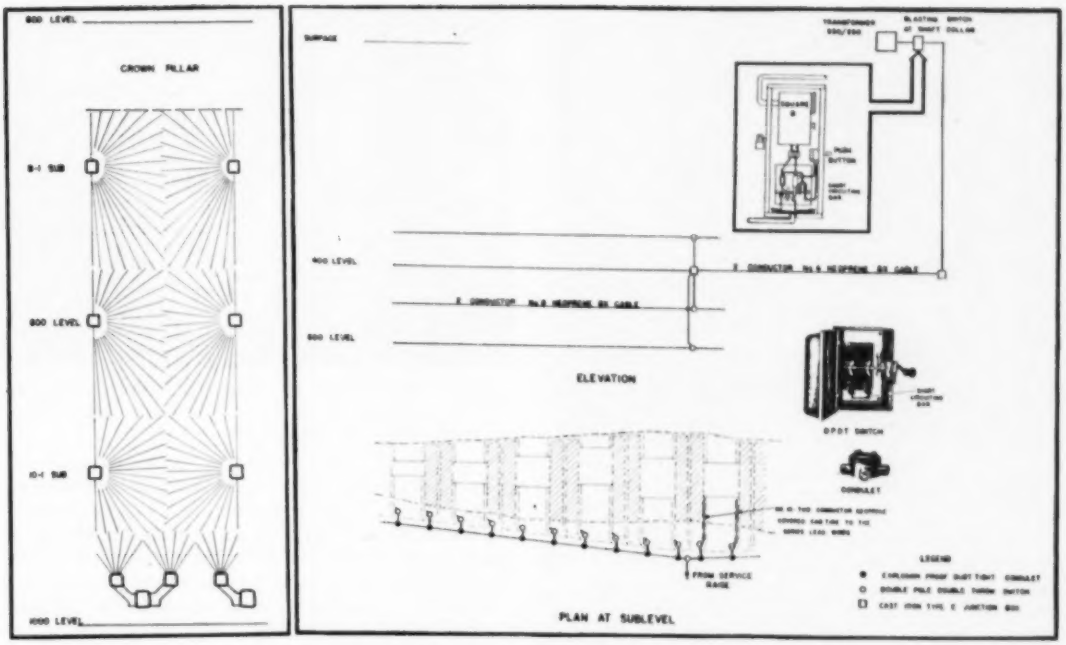


Fig. 23—Blasthole pattern for drilling with tungsten carbide bits. Fig. 24—General arrangement of permanent blasting circuit.

the two methods being determined by the width of the orebody to be mined. Orebodies less than 40 ft wide are mined by longitudinal cut-and-fill stoping. Parts of an orebody that swell to more than 40 ft in width are mined by transverse cut-and-fill stoping.

For longitudinal stoping, and for transverse stoping where an orebody is not more than 100 ft wide, only one extraction drift is needed. Two extraction drifts at approximately 50-ft centers are required for transverse stoping where an orebody is more than 100 ft wide.

Horizontal cut-and-fill stoping varies from the standard square-set-and-fill method only in the changes in technique made possible by mining without sets; deeper breast holes are drilled and more ore is broken per blast; slushing is simplified and overall stoping efficiency is higher. The general layout for a stoping block is identical, as are stope and pillar widths and the layout of chutes and manways. A stope or block of stopes can be readily converted from cut-and-fill to square-set stoping if a change in ground conditions should make the changeover advisable.

The permanent sill floors are the same as in square-set stopes. Pillar fences are built of 5-in. flatted pine posts 8 ft long and slabs 11 ft long. The posts are placed at 2-ft 9-in. intervals; each post overlaps a post in the fence on the floor below by 1 ft and is inclined its own thickness toward the wall to keep the general line of the fence in the vertical plane. The posts are blocked at the top and center to hold them in position and are sheeted with 11-ft slabs. Five-inch flatted pine timbers 11 ft long are used for laying the slushing floors. When mining of a slice has been completed this timber is taken up and relaid on the floor above.

At Garson mine, where stope fill is run of pit gravel, concrete is being used for slushing floors in approximately half the cut-and-fill stopes. In these stopes a 4-in. floor, see Fig. 10, is poured on the fill. The concrete is mixed in the stope in 3-cu ft air-operated mixers using fill gravel and cement in the ratio of 5 to 1, and is poured as soon as possible after the fill is placed to allow plenty of time for the floor to harden before ore is blasted down on it.

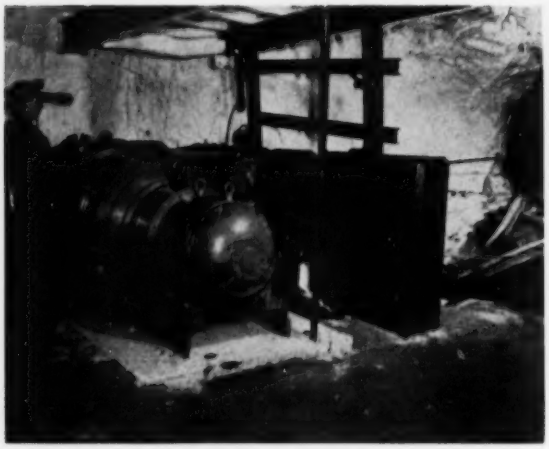
Chutes in cut-and-fill stopes are concrete and are constructed in the same manner and dimensions as those in square-set stopes. On the first ten floors in the stope the chute bottom is made 20 in. thick and the sides and top 12 in. thick. Above the tenth floor the wall thickness is decreased, the bottom being 18 in. thick and the sides and top 10 in. When it becomes necessary to change the inclination of the chute, the thickness of the bottom and top walls is increased to 24 and 36 in. respectively for a distance of 14 ft below the point of change. No wings are built and no grizzlies are used on the chutes. Chute openings at the stope slushing floor are guarded by pipe railings suspended from the back of the stope.

Blasting chambers for use when a *hang-up* occurs are built from each chute to the nearest manway at 5-floor intervals and an opening 20 in. square is left through the wall of the chute at each blasting chamber. The chambers are 3 ft wide and 5 ft 9 in. high inside and are built of special sets framed from 8-in. flatted pine; the sets are lagged on top with 5-in. flatted timber and are sheeted with pine slabs.

Development and Stoping: Standard transverse cut-and-fill stopes are 30 ft wide and pillars are 4 sets wide. There are two manways in a stope, one against each pillar, and one or two chutes, depending upon the number of extraction drifts.

Standard longitudinal cut-and-fill stopes, see Fig. 11, are 200 ft long. Four-set pillars are left between stopes in the wider sections of the orebody, but in sections narrower than 20 ft the stopes are joined together. There are three chutes in each stope, spaced at 58-ft centers, and three manways, one at each end and one near the center of the stope.

All cut-and-fill stopes are silled 30 ft above the base of rail.



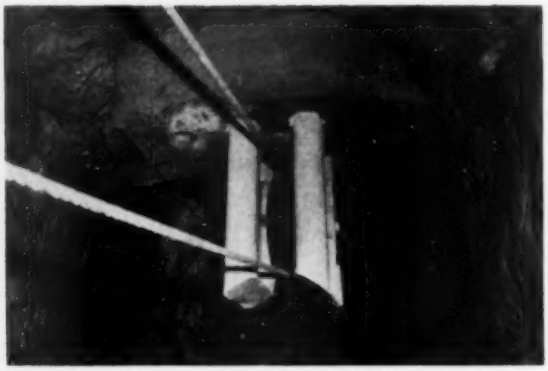


Fig. 25 (left)—A 125-hp slusher hoist slushing to ore pass.

Fig. 27 (right)—A cantilever tail sheave.

Extraction drifts are driven in ore and are timbered with standard two-floor gangway sets. The boxholes are 5 ft square and are driven from the upper floor of the gangway to the stope sill. Openings for the manway bases are made in the side of the extraction drift before the drift is timbered. The manway raises driven from these openings to the sill floor are 7 ft square and are timbered with standard pine cribbing. One 7x11-ft fill raise with a cribbed manway compartment and an open compartment for fill is driven in each stope. In a longitudinal stope the raise is driven in ore on the footwall contact and approximately in the center of the stope along the strike. In a transverse stope the raise is near the footwall beside a pillar.

Detailed exploration in narrow orebodies is done by diamond drilling from a 5x7-ft exploration drift driven along the strike of the orebody at the stope sill floor elevation, either in ore or in the hanging wall rock. When the drift is in ore short connections are driven to the tops of the boxholes so it can be utilized as a pilot drift for stope silling; otherwise a pilot drift is driven at the sill floor elevation from the top of one boxhole to the next.

The sill of the stope is cut 7 ft high and silling is done by slashing to the pilot drift and slushing the broken ore into the nearest boxhole. When the silling reaches the stope fill raise position the raise is begun and is completed by the time the balance of the sill and the second cut in the stope have been mined. Laying the permanent sill floor, building pillar fences, and raising the chutes and manways in preparation for filling the sill floor follows the mining of the second cut.

The slices mined from the back of the stope are 7 ft high. A new slice is started at the fill raise by mining a slot 14 ft wide across the width of the stope, and succeeding blasts are drilled from setups on the broken ore. Drilling, see Fig. 12, is done with 2½-in. piston diameter air-leg drills, and ⅞-in. hexagonal drill steel. The bits are forged integral with the steel and are chisel-type with tungsten carbide inserts. Drill steel is made up in three lengths, 5.25 ft, 10.5 ft, and 15.75 ft. Bit gages are 1.30 in., 1.22 in., and 1.14 in. respectively.

Holes are drilled to break a slice of ore the width of the stope and 15 ft long. The back holes are drilled to form a smooth arch, the holes in the center of the stope being drilled higher than those at the walls. The holes in the rows below are staggered,

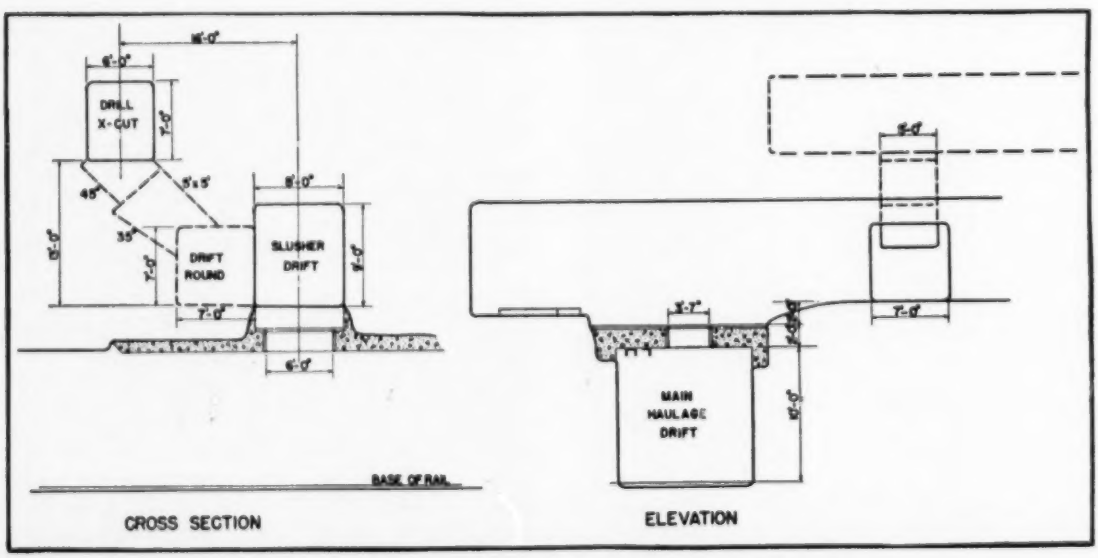


Fig. 26—Section through a slusher drift showing connection to haulage drift.

Fig. 28 (left)—A tail rope idler sheave. Fig. 29 (right)—A concreted slusher drift with 72-in. folding scraper.

but the number to be drilled and the spacing depends on the shape of the breast and overbreak from the previous blast.

For primary blasting, and for secondary breaking when the blockholes and sandblasts are fired with the primary blast, standard explosive is used with short period delay electric blasting caps. For blockholes and sandblasts to be fired independently of a primary blast, 5-ft. tape fuse and No. 6 blasting caps are used instead.

With the short period delay caps, less loose ground develops, hanging wall overbreak is reduced, and better fragmentation is obtained, resulting in lower secondary powder consumption.

Broken ore is slushed to the chutes with a 15-hp air-operated slusher hoist and a 42-in. scraper shown in Fig. 13. Both solid and folding-type cast manganese steel scrapers are used and the cables for both the haul and pullback lines are ½-in. diam.

The slusher is anchored to a heavy timber buried in the fill or by chains to the walls of the stope. As a safety measure for the protection of the slusherman a standard square set is erected around the slusher and a crib of 8-in. flatted timber is built up from the top of the square set to the back of the stope. The broken ore, except for that needed for the drill setups, is removed after each blast.

Fill is run into the stope from the fill raise and is levelled and spread with a slusher for a distance of approximately 50 ft each way from the fill raise. A simple chute is then built in the raise and the balance of the fill is spread with a standard fill car. Track for the fill car is laid with 16-lb rails in 11-ft lengths held together by removable tie plates. Chutes and manways are raised in advance of the filling.

Shrinkage Stoping

In the early days at Inco the major part of the ore produced from underground was mined by the shrinkage stoping method. This was the principal method used at Creighton in mining down to the 1600-ft level below surface, at Levack to the 750-ft level, and at Garson to the 1200-ft level. The method is still in use at Garson mine, and shrinkage stopes have been opened as far down as the 2000-ft level in places where the orebody is relatively narrow. In the wide orebodies at Levack the shrinkage method has given way to blasthole stoping.

Many modifications of the method have been developed and used. The earliest variation at Inco was shrinkage stoping with round pillars and dry-wall drifts. These stopes were silled at the floor of the level to the limits of the orebody, and dry-wall tramming drifts, 7x7 ft inside with chutes spaced at regular intervals, were built as the silling advanced. With the advent of power tramming, extraction drifts with boxholes were driven mainly in ore, and the stopes were silled 25 ft above the level. Round pillars were left in the stopes to support the back, and the stope covered an entire level.

The next development in shrinkage stoping was to reduce the size of the stopes and use rib pillars. In wide orebodies transverse stopes with rib pillars became the standard. The width of the stopes and pillars varied at the different mines from 50-ft stopes and 25-ft pillars to 100-ft stopes and 100-ft pillars. In narrow orebodies longitudinal shrinkage stoping was the practice, but there was no set length for a longitudinal stope, the pillars being established where there was a pinch in the orebody or where the grade of the ore was lower than average.

The present standard in open stoping areas is to mine an orebody less than 50 ft wide by longitudinal shrinkage stoping with subsequent fill, and an orebody more than 50 ft wide by blasthole stoping.

Longitudinal Shrinkage Stoping: Standard longitudinal shrinkage stopes are 130 ft long, measured along the strike of the orebody, and are mined from a 24-ft sill to within 40 ft of the level above. Pillars 30 ft wide are left between the stopes.

Stopes are developed by a 10x10-ft extraction drift driven in ore along the strike in such a location that boxholes opened from the drift will give good coverage of the stoping area at the sill floor of the stope. The drift is driven without timber and is slashed to a finished height of 16½ ft to make room for standard gangway sets.

Boxholes 6x6 ft at 27½-ft centers are driven from one or if necessary from both sides of the extraction drift from the upper gangway sets to the sill floor of the stope. The loading chute is installed after the second round in the boxhole has been

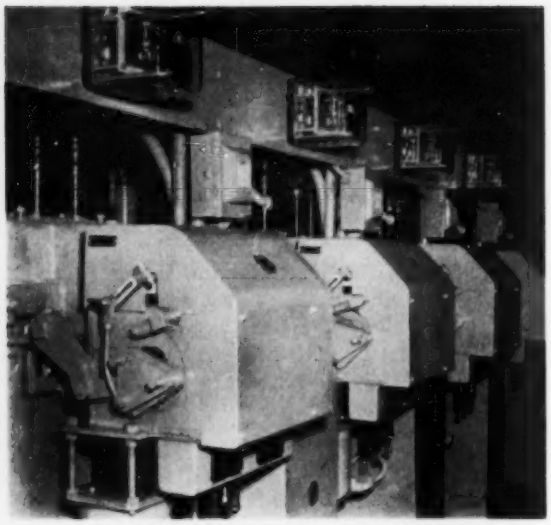


Fig. 30—Circuit breakers in slusher hoist control room.

blasted. The sides of the chute are 10x10-in. timber and the bottoms, built at a slope of 35°, are 6x8-in. timber covered with ½-in. steel plate. The control gate is a cast-steel underslung arc gate operated by an 8-in. diam compressed air cylinder. Supplementing the gate is an 8-in. round stop log suspended horizontally above the gate by chains from the gangway posts.

A 7x11-ft service raise is driven in ore close to the footwall from level to level in each pillar, and as the raise is advanced 4x6-ft connection drifts are driven at 35-ft vertical intervals from the raise into the stoping areas on each side. The raise contains a cribbed manway compartment with ladderway and timber slide, and an open compartment which handles broken ore during the driving and serves as an airway while stoping is in progress. The raises are subsequently stripped and used as passes for ore from crown pillar mining.

Stoping: The stopes, see Fig. 14, are silled at an elevation 24 ft above the base of rail of the level. Two boxholes are driven to the sill floor of the stope and are joined by a 5x7-ft pilot drift. One of the boxholes is used for broken ore disposal during the initial stage of silling and the other serves as a manway while silling is in progress. The rest of the boxholes are driven one at a time as they are needed to keep pace with the silling.

When silling has been completed to one of the pillars a 5x5-ft manway raise is driven from the back of the stope to the first connection drift from the service raise in the pillar. The manway provides access to the stope and is the starting point for mining each slice above the sill.

The second floor is mined in exactly the same manner as in a cut-and-fill stope, and as the broken ore is removed standard sill floor is laid between boxholes. Pillar fences are also built, but are of heavier material than in cut-and-fill stopes and are bolted to the ground to hold them in place when the broken ore is being drawn from the stope.

The fence consists of 8-ft vertical panels of 5-in. flatted jackpine spiked to horizontal bearers of 5x8-in. x 8-ft fir. The bearers are supported and held in place by 1¼-in. diam hooked rock-bolts set 5 to 7 ft into the pillar and spaced at 4-ft centers.

To protect the pillar fences the boxhole at each end of the stope is driven in the second set from the pillar so that as the ore is drawn it will roll toward the center of the boxhole instead of sliding down along the face of the fence.

The sill floor of the stope is filled with waste or gravel to a depth of 8 ft, and upon completion of filling, excess fill is drawn from the stope until cones are formed around the chutes at the angle of repose of the fill. Fill is supplied by way of the open compartment of the pillar raise and the stope manway raise to the stope and spread by slushing.

Shrinkage stopes are mined in a series of horizontal slices, each slice started by opening a cut 14 ft wide across the full width of the stope at the manway raise. Drilling equipment is the same as in cut-and-fill stopes. Holes are drilled 13 to 15 ft deep and are spaced 6 ft apart horizontally and 2 ft apart vertically. They are loaded with standard explosives and detonated with short period delay electric caps.

Slices 8 ft in height are mined until the stope is high enough for the broken ore to settle evenly as the boxholes are drawn. Subsequent slices are mined 10 ft high. Forty per cent of the ore broken is immediately available. As stoping proceeds, broken ore is drawn down ahead of the face to 10 ft below the back to make room for the drill setups and the ore broken in the next blast. As mining approaches the top of the first manway raise, the raise is extended 35 ft to the next manway drift above. When a stope has been mined to the base of the crown pillar, a 5x5-ft fill raise is driven to the extraction drift on the level above and the broken ore is drawn from the completed stope.

After the shrinkage ore has been drawn, waste rock or gravel is dumped into the stope through the fill raise. In the final stage of filling, the fill is levelled off 10 ft below the crown pillar by slushing.

The crown pillar is divided into a series of transverse four-set blocks for recovery by square-set mining. A slusherway is established on the fill from one pillar to the other, and the broken ore from the crown pillar is slushed to one or the other of the two service raises, which are stripped to serve as ore passes.

Rib pillars are mined by the standard square-set pillar recovery method after the crown pillars on each side have been mined out.

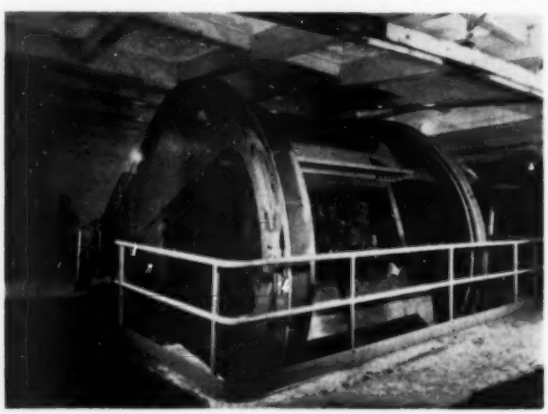


Fig. 31—Rotary tipple dumping 260 cu ft cars.

Sublevel Blasthole Stoping

Sublevel blasthole stoping is being used in open stoping areas for mining low and medium grade orebodies more than 50 ft wide. Used at Levack since 1939 and experimentally in recent years at Creighton the blasthole method has been adapted for mining at the Murray and Frood-Stobie mines. The method has become of major importance in conversion to all underground production, and on completion of the program more than 50 pct of the ore produced will be taken from blasthole stopes.

General Layout

Frood-Stobie Mine, Stobie Section: At Frood-Stobie blasthole stoping is in progress in two separate mining areas, one in the Stobie section and one in the Frood section. The Stobie section is being developed and the new mining plant is being constructed for a daily production of 18,000 tons.

The mine is being developed through No. 7 shaft, the main hoisting and supply shaft, containing two skip compartments, two cage compartments, a pipe compartment, and a manway compartment. A second shaft, No. 8, for ore hoisting only, is being sunk initially to a depth of 1900 ft. No. 8 shaft will be served by a 14-ft 110-in. parallel double-drum geared hoist driven by two 3000-hp, 600-v, 500-rpm, dc motors with rotating-type control. Bottom dump skips of 16-ton capacity will be used and hoisting ropes are to be 2 1/16-in. flattened strand with a breaking strain of 430,000 lb. Hoist operation will be automatic with push button control at the loading pocket as at Creighton No. 7 shaft. Hoisting capacity will be 750 tons per hr. For flexibility of operation both on surface and underground the new shaft has been located within 100 ft of the No. 7 shaft. Underground conveyors carry the ore from the main ore pass system to a loading station at each shaft and the tonnage delivered can be varied in any proportion desired.

On surface, the ore is treated in a common crushing plant and can be conveyed from the receiving bin to either or both of two secondary crushers.

The mine has been opened from levels at 200-ft intervals, and the 600, 1000, and 1400-ft. levels are main haulage levels. Ore is trammed on each of these levels to a crusher station where it is crushed to 6 in. in a 66x48-in. jaw crusher. For each crusher station there is a 2500-ton storage bin. From the crushers the ore falls to the bins and is conveyed as required to one or the other of duplicate systems of vertical passes leading to the loading station conveyor level. To minimize wear the ore passes are kept full, the ore being delivered to them at the same rate it is withdrawn.

The initial stoping block, see Fig. 15, lies beneath the Stobie open pit, where mining has been completed, and extends from the pit bottom to the 1400 level. The orebody in this area varies in width from 250 to 400 ft and dips at 75°. The length of the block is 1000 ft.

Because of its width the block has been divided longitudinally by a 60-ft pillar into two series of 95-ft transverse stopes and 45-ft pillars. The longitudinal pillar is offset on each main level to make the tonnage in the stopes on each side approximately equal. The center lines of the transverse pillars coincide on all levels.

Stopes are being mined on the three main levels. On 600 level they are being broken through to the open pit, and are 195 ft high. On the 1000 and 1400 levels they are being mined to the base of a crown pillar 87 ft from the level above and the height from sill to crown is 312 ft.

The broken ore is slushed into cars on the main haulage levels from slusher drifts, 14 ft above base of rail, to a hanging wall extraction drift from one series of stopes and to a footwall drift from the other. The maximum slushing distance is 175 ft.

Slusher drifts are established at 72½-ft centers, one on the edge of the pillar, the other under the stope. This distance is equivalent to five car-lengths for simultaneous loading from adjacent drifts. For regular stoping, three rows of boxholes spaced at 25-ft centers provide stope coverage. In the drift under the stope boxholes are driven on both sides; in the other drift boxholes are established on the stope side only, those on the opposite side being

Fig. 32—A 20-ton locomotive and train of 260 cu ft tipple cars.

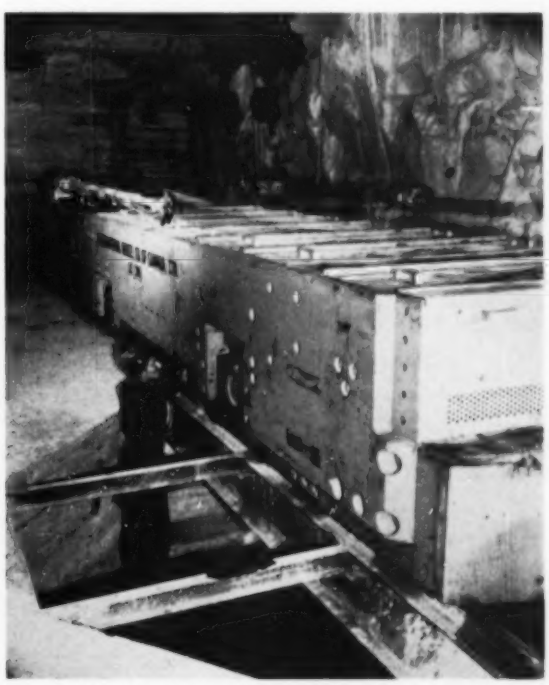


Fig. 33—A 20-ton locomotive in underground repair station.

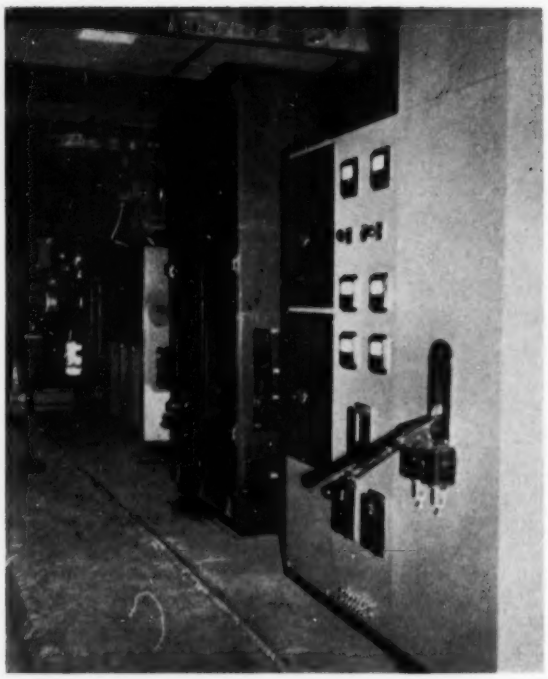


Fig. 34—Underground rectifier station.

driven later for pillar recovery. Sill crosscuts are driven from footwall to hanging wall 14 ft above the floor of the slusher drift on the boxhole center lines, and slot raises from the sill crosscuts connect with the sublevel development.

Service raises, from which the sublevels are established, provide safe access to all stoping faces. They are driven from the main haulage levels, two in each rib pillar, one at the hanging wall, and one at the center of the longitudinal pillar. In addition a raise is driven in rock from the footwall extraction drift at each end of the stoping section.

Sublevel development is established at 100-ft intervals from the service raises; footwall drifts are 6x7 ft in cross section while drill crosscuts located on opposite sides of each stope are 7x7 ft. Broken rock from the sublevel development is slushed to the service raises.

Frood-Stobie Mine, Frood Section: In the Frood section, the portion of the orebody being mined by blasthole stoping is 1200 ft long, 200 ft wide, and dips uniformly at 75°. The block extends from the 1000 level to the bottom of the Frood section of the open pit and has been divided on two horizons, the 600 and 1000 levels, into 70-ft transverse stopes and 70-ft rib pillars, see Fig. 16. Stoping was started on 600 level and these stopes are being broken through into the pit, see Fig. 17. A 78-ft crown pillar is being left at the top of the 1000 level stopes.

The ore on 600 level is slushed to ore passes and the ore on 1000 level is slushed direct to cars for tramming to the 1000 level crusher.

Slusher drifts on both levels are normal to the strike of the orebody and are spaced at 70-ft centers. They are driven on the lines between the stopes and pillars so that, with boxholes at 25-ft centers along one side, two drifts serve each stope. For pillar mining boxholes are driven later along the opposite sides and two drifts serve each pillar.

On 600 level the slusher drifts are driven at the level elevation from a footwall service drift and slushing is toward the footwall. On 1000 level they are 14 ft above the base of rail of the main haulage drifts and slushing is toward the hanging wall.

There are two extraction drifts on 1000 level, one in the footwall rock and one in ore near the hanging wall. Ore from the 600 level is loaded from the chutes in the footwall drift while ore from the 1000 level is handled in the hanging wall drift, to avoid interference when two trains operate in the area.

Drilling sublevels are at 70-ft intervals. Entrance to the drill crosscuts in the stopes is from footwall drifts on intermediate levels connected to the main shaft, and on sublevels from two service raises in the footwall. The service raises are 700 ft apart and extend from the 1000 level to the top of the stoping block. Pillar crosscuts with connections along the hanging wall contact to the drill crosscuts give access to the hanging wall faces of the stopes.

Murray Mine: At Murray the orebody, which is flat-dipping and 200 ft wide, has been divided into 100-ft transverse stoping panels and 75-ft rib pillars. The panels extend from 600 to 1500-ft level and each, see Fig. 18, is subdivided into three and sometimes four stopes by 50-ft vertical cross pillars from hanging wall to footwall between the ribs.

The dip of the footwall is not uniform, being as flat as 25° in places and as steep as 50° in others, with abrupt changes in dip. Advantage is taken of this characteristic in laying out the cross pillars so that they stand on the flat sections of the footwall at the bottom of the steeper slopes.

All slusher drifts are parallel to the footwall; boxhole spacing is 30 ft and maximum slushing distance is 115 ft. For the upper stopes the drifts are in rock under the orebody, one drift in each stope so located that the boxholes break through at the base of the cross pillar. Boxholes from one or more slusher drifts above this complete the stope coverage. The ore from the footwall drifts is slushed into ore passes leading to the main haulage on 1200 and 1500 levels.

For the bottom stope in each section the slusher drifts are in ore and are driven at 65-ft centers under the stope sill from haulage crosscuts in the pillars. From these drifts the ore is slushed into cars.

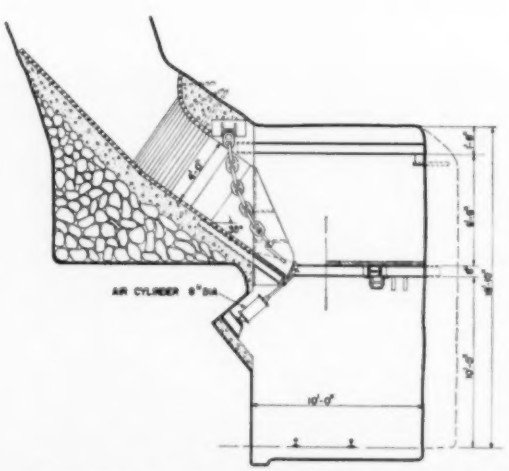


Fig. 35—Detail of ore pass loading chute for blasthole ore.

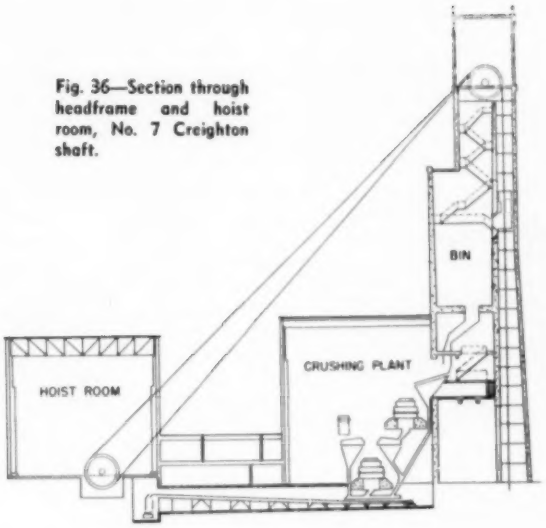


Fig. 36—Section through headframe and hoist room, No. 7 Creighton shaft.

Access to the drill drifts is from the main and intermediate levels and through service raises and drifts in the pillars.

Mining

Stopes are silled by radial drilling from 7x7-ft drifts 14 ft above the floor of the slusher drifts over the lines of boxholes. From the sill drifts radial blastholes are drilled in rings at 2½-ft centers to break a trough-shaped cut over the boxholes. The troughs are 32 ft high and 30 ft wide at the top with sides sloping at 55°, and the face is kept 25 ft ahead of the face of the stope.

The stope slot is established from a 7x11-ft raise from the sill drift to the sublevels above. Slot drifts 6x7-ft in cross section, collared at the slot raise, are driven across the stope from pillar to pillar on each sublevel and widened to 11 ft. The raise is widened to form a slot the full width and height of the stope by blasting vertical holes from the slot drift.

To break an 8-ft slot the blastholes are 2 ft 8 in. apart in rows at 3-ft centers, see Fig. 19. The holes are column-loaded with 1¼x8-in. sticks of 75 pct gelatin dynamite detonated with millisecond delay electric caps.

An alternative method of developing slot raises is being used in stopes which break through to the open pit, see Fig. 20. In this method a 9-in. churn drill hole is drilled from the pit floor to the stope sill and drifts are driven to intersect the hole on each sublevel. With the churn drill hole used as a cut, 7x8-ft raise rounds are drilled from sublevel to sublevel with diamond drills. Starting at the sill and working through to the pit floor, sections up to 25 ft in length are broken in succession from the bottom. Holes are loaded from the sublevel above.

Churn drill holes are also used for opening the section of the slot between the upper sublevel in the stope and the pit floor. Here the slot, see Fig. 21, is broken 18 ft wide across the full width of the stope in one blast. The churn drill holes are blocked 2 ft from the bottom with a concrete plug and are column-loaded to within 10 ft of the collar with 75 pct powder in 12½-lb bags, detonated with primacord and millisecond delay electric caps.

For regular stoping, blastholes are drilled from the sublevel drifts with diamond drills, or percussion drills with tungsten carbide bits. Prior to 1950, the drilling of long blastholes was done almost entirely with diamond drills. Now that bits tipped with tungsten carbide have been developed, drilling in certain types of ground can be done with percussion drills at less cost per foot than by diamond drilling. At the Stobie section of the Frood-Stobie mine and at Levack mine nearly all blasthole drilling is being done with percussion drills, see Fig. 22.

Blasthole Patterns: Blastholes are drilled to allow a primary factor of 0.33 lb of powder per ton of ore broken. For diamond drilling, sublevels are established at 70-ft intervals. Normally the holes are limited to a maximum of 75 ft in length, and up-holes to 15°. Toe spacing is 8 ft.

To break a 5-ft slice of ore radial blastholes are drilled in two patterns: in one the holes are all in one plane; in the other they are in two planes 2½ ft apart with alternate holes of the pattern in one of the planes and the balance in the other.

A slice 25 ft thick is broken in one blast consisting of one full ring 5 ft from the face, eight intermediate rings, and finally a full ring at 5-ft burden.

For percussion drilling, see Fig. 23, sublevel spacing is increased to 100 ft. Down-holes are limited to a maximum of 65 ft, vertical up-holes are drilled to a maximum of 35 ft, and other holes above the horizontal to a maximum of 50 ft. The pattern is similar to that for diamond drilling but the burden is increased to 6 ft to maintain the same primary powder factor.

Primary Blasting: Blastholes are loaded by the drill runners. A length of ½-in. plastic tubing fitted for air and water is used to clean the holes before loading.

The holes are loaded with 75 pct gelatin dynamite. Those drilled with diamond drills are charged with 1¼x8-in. sticks and those drilled with percussion drills are charged with 1½x8-in. sticks. Each hole is loaded solid to within 17 ft of the collar; above that for 7 ft, a 20-in. spacer is used between every three sticks, and in the next 7 ft a spacer is used between each stick of powder. The top of the hole is left open for 3 ft. The powder is tamped with a length of ¾-in. plastic tubing. The detonator is placed in the second stick from the top of the charge.

Short period delay electric blasting caps are standard for primary blasting. Caps are connected in series in parallel, each series limited to 25 caps. Each ring fires in succession, boundary holes being delayed one period behind the rest of the holes in a ring.

Fig. 37—No. 7 shaft headframe and concentrator, Creighton mine.

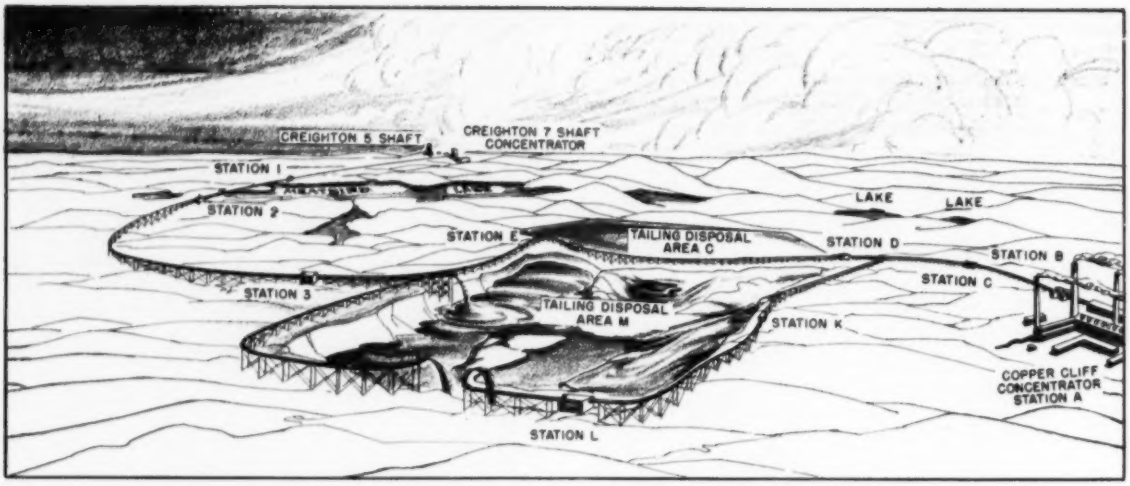


Fig. 38—General plant orientation and system for pumping concentrate and tailing.

The general arrangement of the permanent blasting lines is shown in Fig. 24. Blasts are fired from surface with 220-v ac current through a magnetic switch kept locked when not in use.

Slusher Drift Construction: Except for the discharge opening, drifts for slushing to cars or to ore passes are of the same general design. Usually ground conditions are such that no support is required, but where ground is poor slusher drifts and boxhole brows are completely concreted.

The hoist is set at a minimum of 11 ft from the discharge opening and clearance is left on all sides for operation or dismantling. The width of the hoist room is 15 ft, the length from the discharge opening is 18 ft, and the height below back steel is 7 ft 10 in.

Fig. 25 is a view of a slusher station for slushing to an ore pass. At the discharge end of the drift the hoist room and travelway are protected by an 18-in. concrete wall 3 ft high. An opening left in the travelway side, normally closed by rope guards, permits the moving of equipment in and out of the drift. The hoist is anchored to a concrete foundation with 3-ft bolts extending through the concrete into the rock. At the slusher discharge a manganese steel crusher mantle is set in concrete 2 ft below the floor of the drift. The opening through the mantle is approximately 5 ft in diam.

The general layout of the slusher drift at the discharge for slushing into cars is shown in Fig. 26. The back of the haulage drift is covered with a 24-in. concrete slab in which an opening 3 ft 7 in. x 6 ft is left for the slusher discharge. The surface of the floor slab and the sides of the discharge opening are lined with 2½-in. carbon steel billets.

A ladderway opening in the concrete floor slab provides access to the slusher drift. The slusher discharge is separated from the ladderway and the travelway by a concrete wall 18 in. thick and 3½ ft high.

Tail sheave supports of the cantilever type are installed a minimum of 16 ft beyond the last boxhole, approximately 6 ft from the end of the slusher drift. For removal of ore dragged back to the tail sheave the assembly is centered 9 ft 10 in. above the drift floor to allow the scraper to be swung over the chunks, an arrangement which also reduces rope wear. The sheave assembly, see Fig. 27, set in a hitch and concreted in place, consists of a 20-in. diam cast steel sheave fitted with standard roller bearings and mounted on two 18-in. I-beams. The sheave, designed to pass knotted slusher rope, has a rope groove 3 in. deep, flared to 4 in.; the bottom of the groove is 11/16-in. radius for 1¼-in. rope.

Sheave assemblies consist of cast steel sheaves 6 in. wide and 6 in. in diam fitted with roller bearings and shafts mounted between two semi-circular steel plates. They are anchored with 1-in. diam bolts and concreted in place.

Assemblies are of two types; the first, with two sheaves mounted one above the other to keep the rope from contact with the back of the drift, is installed approximately 20 ft from the tail sheave; the second, with a single sheave, is installed between boxholes at 75-ft centers to carry the tail rope, see Fig. 28.

Slusher Hoists and Auxiliary Equipment: Slusher hoists, for blasthole and caving mining, are 125-hp double-drum hoists with manual lever control. They are designed for a rope speed of 275 ft per min and a rope pull of 15,000 lb and have a drum capacity of 500 ft of 1¼-in. rope. With each slusher hoist is a 3-hp tugger for handling rope and miscellaneous equipment and a sealed beam light for slusher drift illumination. Slusher scrapers are of a 72-in. folding type weighing 3½ tons and haul an average load of 2½ tons, see Fig. 29.

The electrical equipment is located in control rooms, see Fig. 30, on the main levels far enough away from blasting to be protected from concussion.

Circuit breakers are motor-operated, and four hoists are controlled from one room. Power and control cables are run through boreholes from the circuit breakers to the hoists, 3-conductor No. 6 neoprene-covered armored cable for 2200-v power and 6-conductor cable for control and lighting.

Slusher hoists are equipped with 1¼-in. diam used well-drill hoisting rope, secured to the scrapers by a hitch through the pull and tail rope brackets. Hydraulic or mechanical cable cutters are used to cut and trim broken ropes after knotting.

For stowing slusher ropes during blasting operations the tugger hoist rope, strung through eyebolts in the back of the drift and anchored near the tail

sheave, is attached to the slusher rope to hoist it to the back of the drift.

Haulage Equipment: At Frood-Stobie the new haulage equipment for handling ore from blasthole mining consists of 20-ton trolley locomotives and 260-cu ft tipple cars; at Murray the locomotives are 20-ton, but cars are the Granby type, of 188 cu ft capacity.

The locomotives each have two 120-hp, 250-v dc driving motors and are equipped with air brakes; the draw bar pull is 10,000 lb at 8 miles per hr. The tipple cars are 14 ft 6 in. from center to center of coupler, 7 ft wide overall, and 6 ft 7½ in. high from top of rail. Couplers are of railway type, one fixed and the other free to rotate to allow the cars to be dumped without uncoupling. Fig. 31 is a view of a 260-cu ft car being dumped; the tipple operation is automatic with push button control. The 188-cu ft Granby-type cars are 13 ft long center to center of coupler, 7 ft wide overall, and 6 ft 8 in. above the top of rail.

Fig. 32 is a view of a standard 16-car ore train at Frood-Stobie. Three of these trains operate on a main level.

Because of the difficulty of handling this equipment through the shafts, repairs to cars and locomotives are made in underground repair stations, see Fig. 33.

Power for trolley haulage is supplied by 300-kw Hewettic rectifiers, see Fig. 34, which convert power from 2200 v ac to 250 v dc.

Track is standard 85-lb rail at 36-in. gage, laid on 7-in. flatted pine ties and graded at 0.4 pct in favor of the ore load. The track is offset 9 in. from center of drift; walkway clearance is 2 ft 9 in. and clearance on the opposite side is 9 in. Turnouts from the main haulage ways are of 120-ft radius; the minimum radius of other turnouts is 58 ft. The trolley line, 3 ft from center of track, has a 4/0 trolley wire and 4/0 feeder on universal hangers fastened to the drift back support beams. Trolley guards are 1x6-in. boards clamped to the hangers.

Fig. 39—Crack at surface where slice of ore is breaking away from solid.

Fig. 40—Ore disintegration through caving action.

Loading Chutes: Chutes, constructed of concrete and steel, are 5 ft 10 in. wide, with a 4-ft brow opening, see Fig. 35, and lined with 2½-in. carbon steel billets. The ore is controlled by air-operated undercut, arc gate, and chain curtain. The curtain is constructed of six lengths of 2-in. anchor chain weighted with 1½x2-ft steel billets. The gates are cast steel and the operating cylinders are 8-in. diam with 11-in. stroke.

Ventilation: Similar systems of ventilation are used in the Frood and Stobie sections of the Frood-Stobie mine and at Murray.

Efficient ventilation is provided at each mine by a balanced system which has direct connections to collecting drifts at the tail pulley end of each slusher drift so that fresh air enters through the slusher station.

The systems were designed to supply 10,000 cfm per operating slusher drift, with an additional 50 pct for prevention of leakage through non-operating drifts and for the ventilation of development headings.

At the Stobie section of the Frood-Stobie mine where 750,000 cfm will eventually be required, there will be a main intake and three main returns with an axial flow fan mounted at the collar of each raise.

The main intake is a raw raise 21 ft in diam. Two of the returns are also circular raw raises, one being 15 ft in diam to handle 300,000 cfm, the other 17 ft in diam to handle 400,000 cfm; the third return is a raw elliptical raise 9½x16 ft to handle 200,000 cfm. Main airways in the slushing horizons are 10x12 ft, and connections to the main returns are 6x7-ft, 8x9-ft, and 9x10-ft drifts, depending on the volume to be handled.

Normally 75 pct of the fresh air for the stoping area on a level is supplied directly from the intake airway to the slusher drifts through controls at the drift intakes, and the balance is supplied through service raises to the sublevel drill drifts. From these drifts the air downcasts through the stopes to the slusher drifts where it joins the main flow. Controls in the slusher drift exhaust connection are closed when the slusher drift is not operating.

For primary blasting a strong downcast through

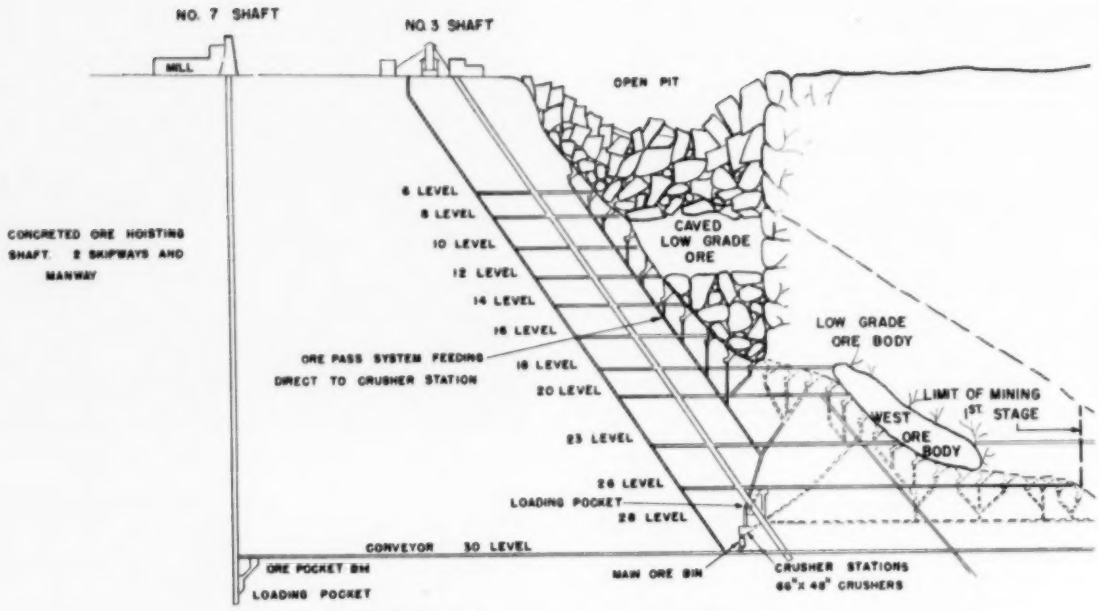


Fig. 41—Diagrammatic section, first stage of caving mining.

the stopes is provided by reducing the volume going direct to the slusher drifts and supplying more air through the drill drifts.

Mining by Induced Caving

The caving method of mining is being used on the upper levels at Creighton mine for the recovery of ore that had long been considered too low in grade to be profitably mined. However, studies and research followed by production on a small scale showed that by using the induced caving method of mining, and concentrating the ore at the mine to reduce transportation costs, recovery of the low grade ore was possible. Consequently when the need arose for quick expansion of underground ore production, planning and development of the large-scale caving project, now producing 10,000 tons per day, was immediately undertaken.

A new ore-hoisting shaft was needed to handle the production from the caving operation. No. 7 shaft, designed for ore hoisting only, was sunk initially to a depth of 2056 ft. It is concrete-lined throughout and has two skip compartments separated by a manway and pipe compartment, an arrangement that allows the hoist to be set up at a minimum distance from the shaft.

Serving No. 7 shaft is a 14-ft 110-in. parallel double-drum geared hoist driven by two 2750-hp, 600-v, 500-rpm dc motors with rotating-type control. The skips have a capacity of 15 tons each and the hoisting ropes are 2-in. flattened-strand with a breaking strain of 380,000 lb. Hoist operation is automatic with push button control at the loading pocket. Hoisting capacity with Kimberley skips averages 650 tons per hr.

The No. 7 shaft headframe, see Figs. 36 and 37, is a concrete structure 197 ft high, and both the headframe and the hoisthouses are integral parts of the concentrator building; ore from the receiving bin in the headframe is fed directly to the concentrator crushing plant. From the concentrator, the bulk concentrate is being pumped through a 7½-mile pipe line, see Fig. 38, to the reduction plant at Copper Cliff.

Underground the initial program included the construction of a crusher station, two concrete and steel-lined bins for crushed ore storage, and an 1850-ft conveyor, as well as the driving of ore pass systems, slusher drifts, boxholes, service raises, and ventilation drifts, and raises needed before the first production could be obtained from the caving area. Further development includes the construction of a second crusher station with ore bin and conveyor, and the extension of the production workings along the strike and down the dip of the orebody.

The ore being mined by caving is the disseminated norite that makes up the major portion of the Creighton ore zone. The dissemination becomes more sparse in the hanging-wall direction and mining will be done to a cut-off grade. The ore occurs as a sheet, with mineable widths up to 600 ft, overlying and forming the hanging wall of the breccia and stringer orebodies. The average dip is 45° and the length along strike is 2200 ft.

An important factor in the successful application of the caving method to the Creighton low grade ore is the occurrence of many intersecting shears and joints. Studies have shown that the average frequency of jointing along any given line is one per ft and that 90 pct of the joints have plane surfaces on which the bonding is weak. Once tensional stresses are set up through undercutting and ore drawing the ore disintegrates, breaking along the joint planes into pieces small enough to be readily handled.

Early Mining: Mining was started at Creighton in 1901 and has conformed closely to the general pattern followed throughout the district. The first ore was produced from an open pit in the outcrop of the breccia ore. When it became necessary to go underground the ore was mined first by open stoping methods, heading, and bench for two levels

below the pit, followed as the mine grew deeper by shrinkage stoping, then by cut-and-fill and square-set stoping.

The open pit reached a final depth of 200 ft. Shrinkage stoping was carried on down to the 40th level, 2600 ft below surface. Below the 40th level all mining has been done by square-set stoping.

From surface to 30 level the breccia ores have been completely mined out. The disseminated ore overlying the mined out area from 28 level to surface will be recovered in the first stage of caving mining.

In this area no floor pillars were left. The vertical pillars were broken up while still surrounded with shrinkage ore. As the broken ore was drawn from the stopes the hanging wall caved gradually and the stopes became filled with caved, disseminated norite.

Pattern of Subsidence: Of particular significance to the present caving operation is the relationship between hanging wall subsidence and mining in the shrinkage area.

In this area there was rapid withdrawal of the ore, especially in the upper levels, so that lateral support was withdrawn from the hanging wall. Slices 100 to 200 ft wide and 400 to 800 ft long were cut off by cracks that developed and widened laterally with no appreciable vertical movement, see Fig. 39, indicating that failure was due to tensional stresses rather than shearing. Once the slice was broken clear, subsidence began and far outstripped the horizontal movement.

At first the face of a slice was fresh and solid, but within a few months interlacing cracks developed within the slice, and as drawing continued tension and torsion combined to open slips and joints till the mass lost cohesion and disintegrated, Fig. 40.

Surveys showed that the thickness of the slices that broke away corresponded to the width of the stoping area from which the ore was being withdrawn. The hanging wall limit of a slice was always vertically above the hanging wall of these stopes. Subsidence at surface has never extended beyond the vertical above the hanging wall limit or the end limits of the area mined out by open stopes.

To induce caving beyond the present limits, the low grade ore will be undercut along the strike and down the dip of the orebody. Undercutting will be done by the blasthole method. Starting at the face of the caved area, panels will be undercut along the lines of boxholes from the slusher drifts. The rib pillars between the panels will be blasted out in sequence from the bottom of a section towards the top along the dip of the orebody.

Fringe stopes are not considered necessary. Experience indicates that as the broken ore in the caved area is drawn, the ore above a new undercut will be put in tension and will crack through to surface breaking away from the solid and disintegrating as drawing is continued.

Experimental Work: The manner in which the hanging wall subsided and the rock disintegrated indicated the possibilities of caving mining at Creighton, but many problems remained to be solved.

It was apparent that mining the low grade ore would be simplified in some ways and complicated in others because the higher grade ore underlying the low grade had been mined out. The low grade ore was undercut except where there was overlapping at the ends of the ore zone, so that many millions of tons of caved ore lay ready to be drawn. On the other hand the old mine openings would interfere with an orderly arrangement of openings for the new program. Some of the problems were solved in the laboratory by experiments in which scale models were used that embodied the factors anticipated in actual underground mining while others incapable of solution on a laboratory scale were worked out in pilot operations underground.

Fig. 42—Composite plan, first stage of caving mining.

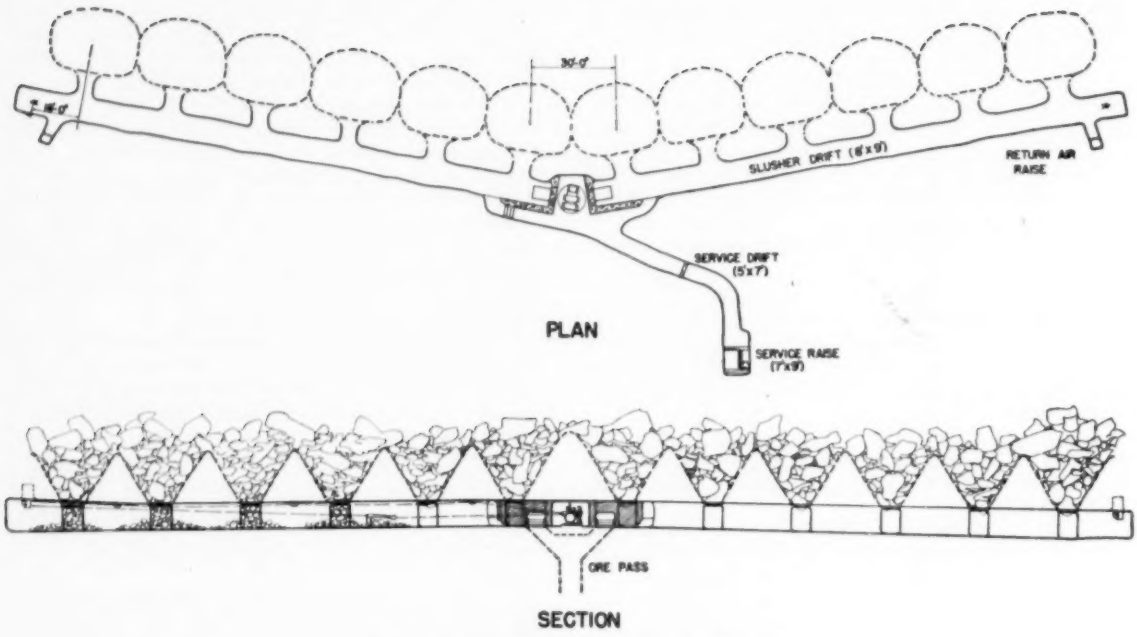


Fig. 43—General arrangement for two-way slushing.

It was decided that any of the old openings which interfered with the new development program could be walled off by concrete bulkheads.

Experimental work on ore drawing in caving showed that as ore is drawn from a stope chute the draw pattern in the stope for a height of 200 ft vertically above the chute is cone-shaped, the slope angle of the sides of the cone being 77°. Above 200 ft the pattern is cylindrical, the cylinder having a 125-ft diam.

Experiments also demonstrated that to minimize dilution it is better to draw small quantities of ore from each chute in rotation. This lowers the mass of broken ore without disturbing the contact between the ore and the capping. Concentrated drawing of a few chutes causes early dilution. It was also shown that boundary chutes should be drawn more heavily than internal chutes when the boundary is ore in place, and less heavily than internal chutes when the boundary is caved capping.

General Layout: The low grade ore for a height of 1750 ft from 28 level to surface is being recovered in the first stage of the caving program. Fig. 41 is a diagrammatic section showing the first stage of caving mining.

The ore flows by gravity to the 28 level where the primary crushers are located. They are 66x48-in. crushers driven by 300-hp motors and have a capacity of 590 tons per hr crushing to 6 in. From each crusher the ore falls tc a 1500-ton concrete-lined bin on 30 level and is fed from the bin to a 48-in. conveyor carrying the ore 1850 ft to the loading station storage bin at No. 7 shaft.

The orebody has been divided along the strike into six 350-ft mining sections, see Fig. 42. For each section there is a service raise system, a ventilation raise system, and a main ore pass with 20 or more branches leading to as many slusher drifts in the footwall.

The ore pass is a compound raise which, starting from the crusher station, is made up of 75 to 135 ft of 37½° slide, 250 to 400 ft of 65° raise, and 1000 to 1200 ft of 47° raise with branches to the slusher drifts. Each pass is on the center line of a mining section. The passes feed to the crusher stations and each of the long slides at the bottom reaches across from the main part of the pass to a station. The slides are concreted and are lined with 3-in. nickel alloy steel wear plates. The upper portion of the passes is made flat to keep the branch raises short, and because of the low inclination no ore is allowed to accummulate there. Storage is in the 65° portion and varies from 1000 to 2000 tons.

Slusher drifts, designed for two-way slushing, are made up of two branches running parallel to the footwall in opposite directions from the ore pass. Each branch is approximately 175 ft long. The drifts are spaced in plan at 40-ft centers and the vertical distance between them varies with the inclination of the footwall. The boxholes are at 30-ft centers along the hanging wall side of the drifts and the slusher stations are in the center directly over the branch ore pass.

The service raise system is made up of a series of raises each approximately 500 ft long. The raises are 50 ft from the slusher drifts on the footwall side and are connected by service drifts to the slusher stations on all slusher sublevels.

The collecting raises of the ventilation system are in the footwall on the boundaries between the mining sections and are connected to opposite branches of the slusher drifts in two mining sections.

The original mining between 2800 level and surface was done through No. 3 shaft, which has been reconditioned and is being used for handling men and supplies. The main levels from No. 3 shaft were driven at 120-ft intervals with sublevels between where necessary. Much of the old development from No. 3 shaft is being used in the new mining program.

The two central mining sections in the low grade area are now in production, and mining will be

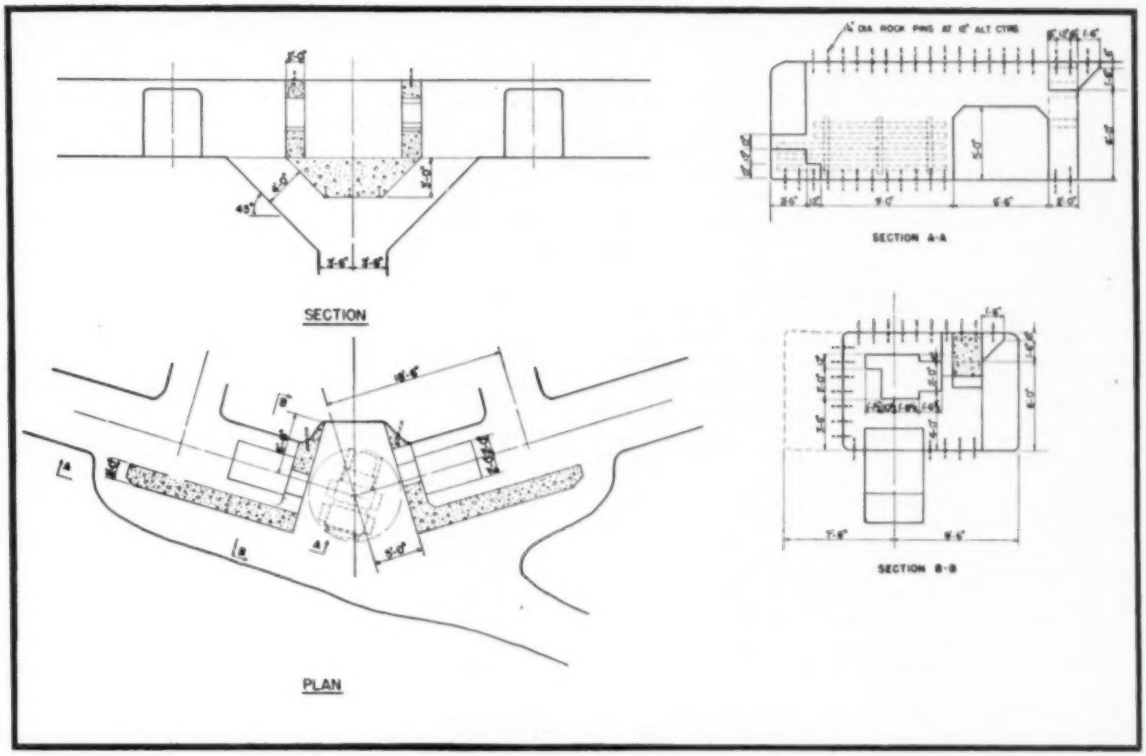


Fig. 44—Detail of slusher station and discharge openings.

started in the other sections as quickly as possible, since it is planned to draw the caved ore on a continuous front along the full length of the orebody to avoid the dilution that occurs where boundaries are formed between waste and ore.

Development: In each section development is completed over the entire area served by an ore pass so that when the section goes into production there will be a minimum dilution of the ore by development waste. The large amount of preparation required before any production is possible makes it necessary to concentrate this work on one mining section at a time. From 20 to 25 slusher drifts must be developed simultaneously. The ore pass and service raise are driven first. They are divided into lifts of 300 ft driven simultaneously from service drifts extended from existing footwall drifts on the old levels. Each lift is driven as a two-compartment stulled raise, containing a manway compartment and a chute compartment. The manway in the raise is above the chute and 5-in. flatted pine stulls slung in steel stirrups are placed horizontally at 5½-ft centers on a line 3 ft from the back of the raise to support the ladders and the timber slide. A main ore pass raise is 7 ft wide and 9 ft high, the branches being 7 ft square except for the last 10 ft, which are 4x4 ft square.

The service raises are 9 ft wide and 7 ft high. They are retimbered upon completion and divided into a manway compartment and a compartment for hoisting supplies. The permanent timber consists of 8-in. flatted pine footwall plates and dividers with 3-in. plank brattice nailed to the dividers between compartments. The track in the hoisting compartment is 40-lb rail at 24-in. gage.

The service drifts on the slusher sublevels are driven 5x7 ft. They are collared as the raise is advanced, and after the raise is completed they are connected to the branch raises at the slusher station locations. To protect the service raise from the effects of blasting a turn is made about midway along each drift; in addition a baffle is constructed consisting of 8x10 timbers placed vertically and dapped into 8-in. channels in concrete at the floor and back of the drift. The channels have a short section of flange cut away for easy changing of the timbers.

Slusher drifts 8x9 ft are driven and the boxholes completed before slusher station construction is started. Boxholes are normally 18 ft long and 8x12 ft at the throat and are belled where they enter the ore zone. A boxhole more than 50 ft long is driven as a 7x11-ft cribbed raise, and a 4x6-ft blasting drift with 4x4-ft manway raise from the slusher drift established on the footwall side of the boxhole.

Slusher Drifts and Equipment: The general arrangement of a station and slusher drifts is shown in Fig. 43. The detail of the slusher station and discharge openings is shown in Fig. 44.

The slusher discharge openings for each of the drifts are made by widening the 4x4-ft portion of the ore pass below the break through to form a V 4 ft wide and 26 ft long with ends sloping to the raise at 45°. The center of the V is bridged with a concrete slab 3 ft thick which becomes the floor of the slusher station and the foundation for the slusher hoist. Two L-shaped concrete walls enclose the discharge ends of the slusher drifts and separate them from the station. The slusher hoist

is mounted on a turntable and clearance of 10½ ft between the end walls allows it to be turned through 180°. The walls of the station are 2 ft thick and are anchored to the rock with steel pins. The side walls are lined for 3 ft from the bottom with salvage 60-lb rail placed horizontally at 9-in. centers. Openings for the slusher ropes are left in the end walls. Opposite the slusher discharge, openings left in the side walls for moving equipment in and out of the slusher drift and for convenience in barring are closed to a height of 3 ft above the floor with 5-in. flatted timbers held in slots in the concrete at the sides of the openings.

The entrance to each slusherway is at the end of the side wall over a 3-ft curb that prevents ore from spilling out into the travelway. A stairway on the outside and toeholds and handholds inside at the entrance are provided for climbing in and out of the drift.

The slusher hoist turntable arrangement utilizes castings. With a 1-ft skid plate bolted to the bottom of the frame the hoist is mounted on a set of radial castings anchored to the floor slab. The castings are machined to give a smooth surface under the skid plate and are carefully levelled and grouted in place. The hoist and skid plate are anchored to the castings by bolts inserted from the top through both the hoist frame and the plate. The nuts for the hoist anchor bolts are elongated to keep them from turning and to provide good bearing against the shoulders of the T-slots in the castings. To keep the hoist centered as it is swung around, the skid plate turns about a pivot pin at the center.

The electrical connection to the motor is made with a piece of 4000-v rubber-covered flexible power cable long enough to permit the hoist to be turned without disconnecting the motor leads.

Slushing equipment for caving is the same as that used in sublevel blasthole stoping.

The electrical equipment is located in control rooms on the main levels far enough away from slusher-drift blasting to be protected from concussion. The circuit breakers are motor-operated and as many as eight hoists may be controlled from one switch room. The power cables and control cables reach the hoists through the service raises and manway drifts or through boreholes.

All blasts are fired electrically. For blasting in several drifts simultaneously a permanent ungrounded 110-v blasting circuit is installed in each service raise with junction boxes at the slusher drifts and a standard shot-firing switch at each of the slusher hoist switch rooms. When a blast is confined to one drift a 10-shot blasting machine is used.

Operation of Slusherways: The crew consists of a slusherman and a helper for each slusherway. Pieces of ore too large to be slushed into the raise are broken in the drift by sand blasting and hangups in the boxholes are brought down by pole blasts.

For draw control the slusherman records the number of scraper loads of ore taken from each boxhole. Approximately 2000 tons are slushed from each of six boxholes in one branch of the drift before the hoist is turned, and an equal tonnage drawn from the boxholes in the opposite branch. The hoist must be turned about once a month. The slusherman and his helper, using the tugger hoist mounted on the slusher and a set of double blocks, can complete the operation in about 2 hr.

Slusher hoist greasing and inspection is done by special service men who are directly responsible to the mine supervision. Major repairs are done by electrical and mechanical department personnel.

Ventilation: Efficient ventilation is provided by an exhaust system which has direct connections to the collecting raises at the tail-pulley end of each branch of the slusher drift so that fresh air enters through the slusher station.

The system was designed to exhaust 10,000 cfm per slusher drift operating. The fan is mounted on the collar of the return air raise. It is a 124-in. diam axial flow fan rated at 300,000 cfm against 5 in. of water at 440 rpm and is driven by a 350-hp totally enclosed pipe-ventilated vertical motor. The impeller is hung below the motor on the fan shaft extension and is equipped with stainless steel adjustable pitch blades which can be varied to operate over a range of 2¼ to 5½ in. of water at rated volume.

From the top slushing horizon to surface the main return air raise is circular and 15 ft in diam. It is connected on 5 level by 10x12-drifts to two return air raises 120 sq ft in cross section that will also handle the exhaust air from the second stage of the caving program. The other return raises, for use in only the first stage of the program, vary in size from 5x5 ft to 7x9 ft. The transfer drifts, joining these raises to the central returns, are 8x9 ft and 9x10 ft.

Fresh air from surface is drawn down through the caved area and footwall development to the various levels and reaches the slusher station through the connecting manways and supplyways on the slusher sublevels. The flow of air through each operating slusher drift averages 175 ft per min.

In the exhaust connection from each drift a reinforced concrete bulkhead is installed, with an opening which can be varied in size to maintain an average flow of 10,000 cfm. The opening is closed to travel by a steel rod grid and is provided with a cover of salvage conveyor belting that is closed during periods when the slusher drift is not in operation. When mining from a drift is completed the bulkhead is sealed with a steel plate.

The system of return airways is entirely separate from all operating development openings, and a high efficiency is maintained without difficulty.

Drainage: Surface water that runs into the caved area drains through the boxholes into the slusher drifts. If allowed to enter the ore passes it causes great difficulty in handling the ore.

The slusher drifts are graded at 1½ pct down from the discharge openings and the water flows through the ventilation raises to the mine drainage system. Any pools of water which collect between operating periods are pumped dry before slushing is resumed.

Sequence of Extraction: In each mining section 5 to 8 slusher drifts in sequence are in operation at one time. Commencing with the upper sublevels, each drift down the footwall is depleted in turn, to be replaced by a new drift brought into production at the bottom of the sequence.

The capping follows the descending ore, forming a plane extending from the hanging wall above the lowest producing slusherway to the footwall. This plane of retreat is kept as uniform and as flat as possible and its pitch is determined by the number of producing slusher drifts.

Scale models based on the recorded tonnages drawn from each boxhole are used to control the inclination and uniformity of the plane of retreat.

Sponge Iron at Anaconda

by Frederick F. Frick

SPONGE iron as produced at Anaconda is a fine, −35 mesh, impure product, about 50 pct metallic iron, obtained from the reduction of iron calcine at a temperature of 1850°F by use of coke resulting from slack coal. The metallic iron particles are bulky and spongey and precipitate copper readily and rapidly from a copper sulphate solution. Investigation of the treatment of Greater Butte Project, Kelley, ore at Anaconda early showed the desirability of using sponge iron as a precipitant for the copper in solution resulting from desliming of the ore in a dilute sulphuric acid solution.

Anaconda had done considerable work on the production of sponge iron in 1914 for use as a precipitant of copper from leach solutions. Some success and considerable experience were attained at the time, indicating that sponge iron might be successfully made by a modification of the process used in 1914, a batch process in which an iron calcine was reduced by means of soft coke, resulting from noncoking coal, in a Bruckner-type revolving horizontal cylindrical furnace widely used 50 years ago. The coke and calcide formed the bed in the Bruckner furnace, which was rotated at about 1 rpm. The bed was brought to a temperature of about 1800°F by means of an oil flame over the surface. Although results were reasonably satisfactory, they did not warrant full development of the process at that time.

A good deal of work has been done in the last 50 years on the production of sponge iron. The objective in some cases has been the production of a precipitant for copper from solution, but the bulk of the work has been done for the production of open-hearth steel furnace stock. The production of an open-hearth stock presents two problems rather than one: first, production of the sponge iron, and second, what is perhaps of equal difficulty and importance, conversion of the sponge iron into a form suitable for use in the open-hearth furnace. So far as is known to the writer, none of the sponge iron processes tried in the past have proved to be economically feasible. However, Anaconda had a combination of conditions appearing to justify an attempt to produce sponge iron which would serve for the leach-precipitation-float process. It was thought that the process used in 1914, if changed to a continuous one, might work out satisfactorily. The following favorable conditions at Anaconda justified the investigation: 1—A sufficient tonnage of good grade iron calcine resulting from the roasting of a pyrite concentrate in one of the acid plants, at substantially no cost. 2—Reasonably cheap natural gas. 3—The fact that there was no need for production of a high grade product. 4—The fact that there was no need for obtaining a consistently high reduction of the iron in calcine.

A small revolving Bruckner-type furnace about 2 ft ID by 4 ft long was set up for early pilot work at the research building. This pilot furnace showed that a satisfactory product could be obtained at reasonable cost. It also indicated a marked advantage in preceding the reduction furnace with a furnace of similar size and capacity for preheating and roasting out any residual sulphur from the feed. The small furnace was operated for several months, various details of the process were worked out, and sponge iron was produced to supply a pilot LPF plant which treated 300 lb of Kelley ore per hr. Later a second pilot furnace 5 ft in diam and 12 ft long inside was set up at our reverberatory furnace building. This furnace confirmed the data of the small furnace and gave a basis for design of the final plant.

At Anaconda a pyrite concentrate, running about 48 pct S, is recovered from copper concentrator tailings by flotation. This concentrate is roasted to sulphur of 3 pct or less at the Chamber acid plant. The iron calcine contains about 57 pct Fe and 18 pct insoluble.

The iron calcine feed, as mentioned before, is reroasted and preheated in a reroast furnace preceding the reduction furnace. Both are of the Bruckner type. The reroasted calcine is fed into the reduction furnace at 800° to 1000°F along with 30 pct slack coal. In the feed end of the furnace the volatile is burned from the slack, giving a soft coke which readily serves for reduction of the iron. Hard metallurgical coke will not serve the purpose, since it does not reduce CO_2 readily at a temperature of 1850°F. All indications are that the actual reduction of the iron is accomplished by carbon monoxide below the surface of the bed, which is 30 in. deep at its center. Apparently there is a constant interchange:

$$Fe_2O_3 + 3CO = 2Fe + 3CO_2. \quad CO_2 + C = 2CO$$

Actually iron oxide is reduced by CO at somewhat lower temperature than the 1850°F used in the process, but this temperature is necessary to obtain a satisfactory rate of furnace production. The furnace atmosphere is generally reducing, and typical blue carbon monoxide flames satisfactorily cover the bed. Gas flames from four 3-in. Denver Fire Clay Inspirator burners are played directly on the bed, which is slowly cascaded by the 1 rpm of the furnace. An excess of coke is necessary to assure maintenance of good reducing conditions in the furnace bed. Part of this coke is recovered for re-use.

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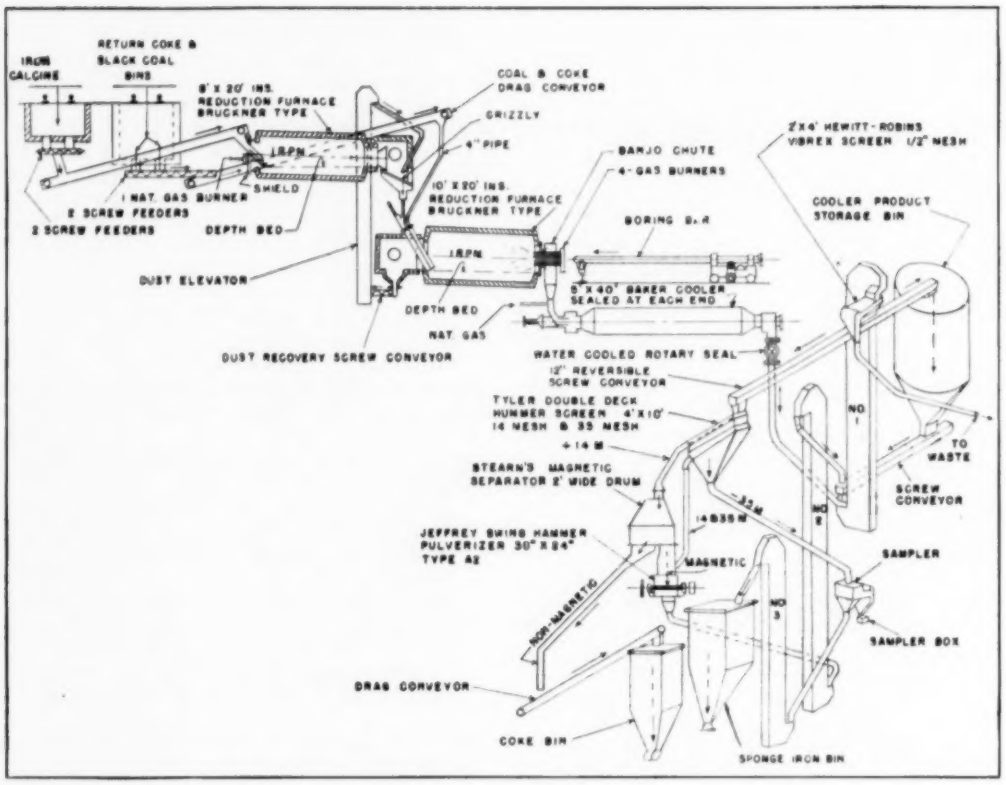

Fig. 1—Anaconda sponge iron plant.

A satisfactory final sponge iron product involves two steps, production of the iron, and prevention of reoxidation during cooling. The firing end of the furnace is almost entirely enclosed and the product overflows at the firing end into a receiving duct in which raw gas is passed to maintain a reducing atmosphere. The furnace product passes from the duct directly into a Baker cooler where it is cooled from about 1500°F down to about 150°F. The Baker cooler has rotary seals at both ends to exclude air and prevent reoxidation of the sponge iron. It has given marked satisfaction.

Table I. Production of Sponge Iron at Anaconda Copper Co.

Operating Data				
Tons calcine feed per day			65	
Tons final product per day			45	
Tons slack coal per day			20	
Tons return coke per day			5	
Mcf gas per day			300	
Pct iron reduced			72	
Bed temperature, degrees F			1850	
Analyses	**Fe, Pct**	**Fe°, Pct**	**S, Pct**	**Insoluble, Pct**
Feed	58		0.50*	18
Final product	70	50	0.8	24

* Reroast to reduction furnace.

One of the essentials for satisfactory production of sponge iron is a low sulphur content of the feed to the reduction furnace. The sulphur content of the feed should not exceed 1 pct, see Table I. A larger amount gives wall accretions, ball formation in the bed, and a dark inferior product which gives a poor efficiency in precipitation of copper.

Both pilot plants indicated the need for a boring bar in a commercial plant. At the 1850°F temperature necessary for satisfactory production from an individual furnace, there is a tendency for the formation of accretions on the walls of the furnace, and it is not feasible to remove these accretions by hand barring. A mechanically operated water-cooled boring bar was designed which enables removal of the accretions in a very satisfactory manner. At the outer end of the boring bar there is a knife 1 ft wide which is brought to within about ¾ in. of the brick lining of the reduction furnace, at the firing end. The knife is advanced horizontally at a rate of 1 ft per min. The revolution of the furnace gives the knife a spiral path on the inner surface of the furnace and the accretions are cleanly shaved off.

The cooled furnace product requires preparation for use, principally reduction in size to −35 mesh and recovery of excess coke for return to the reduction process. Size reduction is desirable to reduce the tendency of sponge iron to sand out in the flotation cells of the LPF plant. Processing, shown in Fig. 1, has presented no serious problems.

To summarize, the production of sponge iron has proved satisfactory both technically and economically. The capacity of the plant has not yet been determined. There is little doubt that the operation will be improved as time goes on.

Acknowledgment

The production of sponge iron was developed by the Research Department. The successful outcome of the project is due to the untiring efforts of F. L. Holderreed, Assistant Research Engineer.

Principles of Present-Day Dust Collectors And their Application To Mining and Metallurgical Industries

by J. M. Kane and R. H. Walpole

IN all probability the mining and metallurgical industry as a whole can demonstrate a larger economic return from installation of dust-control equipment than any other major industrial group. This fact has partially accounted for the marked increase of dust-control installations made during the past decade. While the primary objectives for installation of dust-collecting systems are improved working and operating conditions for men and equipment, the fact that an economic return can be anticipated on salvageable materials is an added advantage which shows in partial or complete equipment write-off. The conditions apply to most phases of the mining, milling, and smelting industry, both nonmetallic and metallic.

As with any mechanical devices, selection of suitable dust collector equipment involves evaluation of available products with characteristics most nearly meeting conditions of the application at hand. When there is valuable product to be collected, and/or when there are possibilities of air pollution or public nuisance, collector selection is often guided by the maxim of "highest available collection efficiency at reasonable cost and reasonable maintenance." A brief review of dust collector designs will permit outlining of major characteristics of each group. Final selection will involve detailed data against a background of the problem under consideration.

The dry centrifugal collectors, see Fig. 1, represent a group of low cost units with minimum maintenance. They are subject to abrasion under heavy abrasive dust loads and to plugging with moist materials. Efficiency drops off rapidly on particle sizes below the 10 to 20 micron group. Because of the large amounts of −10 micron particles in most mining dust problems, they will normally be used as primary collectors and will be followed by high efficiency units. This combination is especially popular where the bulk of material is desired in a dry state with wet collection indicated for the final cleanup portion. In remote plant locations, dry centrifugals can be used alone if product in dust form has no value or if dust loading is light enough to eliminate a nuisance in the plant area. Where high efficiency dust collection equipment must be selected, choice will normally involve fabric arresters, wet collectors, or high voltage Electro-Static precipitators.

Fabric arresters, see Fig. 2, rely on the passing of dust-laden air at low velocity through filter fabric. Velocity ranges from 1 to 3 fpm for the usual installation and may be as high as 10 to 20 fpm in arrangements where automatic frequent vibration or continuous cleaning of the filter media is employed. Fabric is normally suspended in either stocking type or in an envelope shape. Collection efficiency is excellent even on sub-micron particle sizes. Equipment is bulky, must be vibrated to remove the collected dust load, and is restricted in applications from temperature and moisture standpoints. Condensation of moisture on the fabric filter media causes plugging of the passages with great reduction in air flow. Temperatures for the usual medias of cotton or wool are 180° and 200°F maximum, although the introduction of synthetic materials such as nylon, orlon, and glass cloth have increased the possibilities of this type of collector for higher temperature applications.

The wet-type collector may employ a number of different principles so that entering dust particles in the gas stream are wetted and removed. Principles usually include impingement on collector surface or water droplets, often in combination with centrifugal forces. Variety of wet collector designs is indicated by typical collectors illustrated in Figs. 3 and 4. Collection efficiency is a function of the particular design, although the better collectors will have high collection efficiency on particles in the 1-micron range. Wet collectors have the advantage of handling hot or moist gases, take up small space, and eliminate secondary dust problems during the disposal of the material. At times collection of the material wet is a disadvantage. Wet collectors may also be subject to corrosion and freezing factors.

The high voltage Electro-Static precipitator, see Fig. 5, is probably the most expensive type of high efficiency collector. It finds its applications generally in problems in which collectors previously discussed cannot be employed. Its collection efficiency is based on its design features and can be excellent on the finest of fume particles. Material is normally collected dry. Gas temperatures are of no great concern as long as condensation does not occur within the dry type of precipitator and the temperatures do not exceed the limits for materials used in its construction. As with the fabric arrester, provisions

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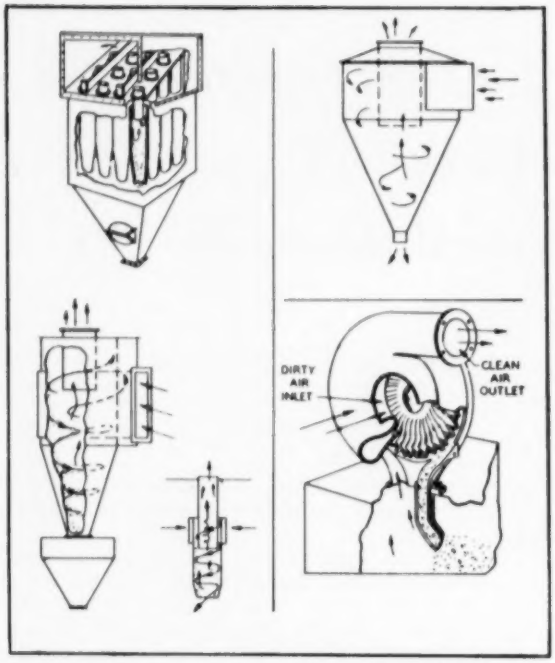

Fig. 1—Dry-type centrifugal collectors. Upper right, low pressure cyclone. Lower right, dry-type dynamic precipitator.

must be made for periodically removing the collected dust load and for disposing or transferring a dry product from the storage hoppers.

Handling of materials from the mine process through operations of secondary crushing, smelting, sintering, and roasting requires local exhaust ventilation to remove air-borne dust. Clean air reduces occupational hazards and permits ideal working conditions for maximum labor output. Dust is released during dry material transfer from one element of the system to a second and also from operations involving such processes as crushing and screening. The logical means of reducing atmospheric contamination is by localized control. This is achieved by enclosing the dust dispersion source and exhausting sufficient air from this hood or enclosure. Pring in a discussion of this subject effectively illustrated that there is a need for large enclosures and the proper location of exhaust connections, as can be noted from Fig. 6. With restricted hooding near the belt, excessive material will be picked by the exhaust system. The cushioning effect of breaking the fall of ore before it hits the belt can be noted by the need for additional exhaust at the back side of the chute in the latter case.

The degree of enclosure is frequently a function of the operation, generally a compromise between views of operating personnel who would like no enclosures to impede maintenance and inspection and those of the dust-control engineer who would like to house all equipment completely. Obviously complete enclosures would be the most desirable from a standpoint of dust-collecting requirements, but these are seldom possible because of required access, inspection, and material flow.

Consideration must be given to the cause of dust dispersion. For example, ore falling from the head of a conveyor to a feed point on a conveyor below sets up an air flow in the direction of fall. To prevent release of this volume with its load of dust particles, exhaust volumes of from two to ten times the material volume must be expended in addition to the exhaust volume required to keep an indraft through all openings in the enclosure at the skirt boards of the second conveyor. The variables controlling the induced air volume are many and include such factors as size and surface area of the material, height of fall, and free-opening area surrounding the enclosure. The problem has been the subject of considerable field research, with indications that more accurate data for the guidance of the mining dust control engineer will be available in the near future.

A survey of many dust control applications covering material-handling operations in the mining group indicates the concentration of accompanying dust can vary widely. Factors such as system design, moisture content of mine run ore, and pickup velocities influence amounts of material to be handled by the dust collector. This may vary from 0.5 to 15.0 grains per cubic foot. Tests on typical dust collecting exhaust system controlling a secondary copper ore milling operation indicate concentrations of from 4 to 7 grains per cubic foot. Tests on a lead-zinc cone crusher exhaust system reported loadings of 15.0 grains per cubic foot.

By way of illustration, dust control benefits in the potash industry may be cited. Without an exhaust system, the dust escaping from conveyor belt transfer points handling finished potash completely filled a surrounding tunnel area. This necessitated daily removal of accumulated potash, requiring approximately 3 man-hr per day. Through control of air-borne dust at the source by local exhaust ventilation, the tunnel is now consistently clear, the collected material is redistributed on the conveyor belt, eliminating the possible contamination of the products, and 15 man-hr per week direct labor cost are saved.

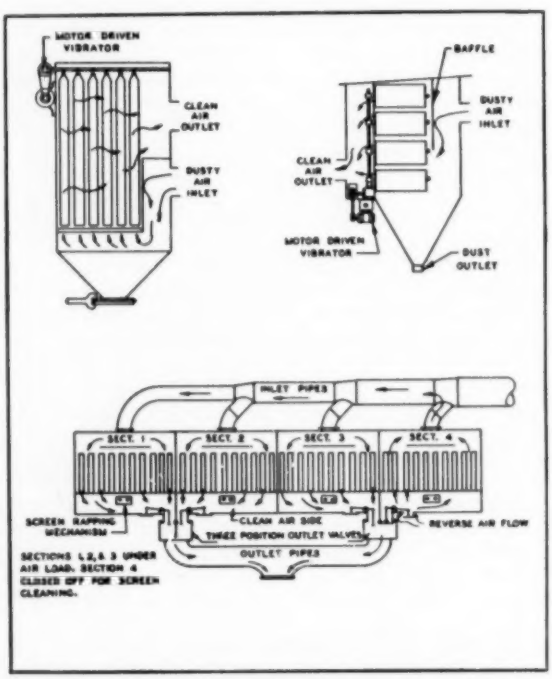

Fig. 2—Fabric arresters. The multiple section continuous automatic, the cloth tube or stocking type, lower left, and the envelope or bag type, upper right.

Some conveyor belt transfer points on smelting and roasting operations indicate concentrations down as low as 1 grain per cubic foot and as high as 10. The velocity at the enclosure takeoff frequently has a decided bearing on the dust concentration to be handled by the exhaust system. While the normal carrying velocity in an exhaust duct system is 3500 to 3700 fpm, if this velocity were maintained throughout the enclosure, the pickup rate would be excessive. Experience indicates that the takeoff velocity from hoods should be reduced to a point where only the airborne dust is removed. This is generally in the neighborhood of 500 to 700 fpm with an exhaust transition section designed to permit a gradual increase in velocity from this rate to the carrying velocity in the exhaust system ducts.

The selection of the type of collecting unit requires an analysis of the basic collecting units discussed above with specific reference to the problem being studied. In many applications in the mining and milling industry, material must be collected wet or dry, depending on the salvage method. This frequently is the governing factor for the selection of a wet or dry collecting unit. In screening and crushing operations, more emphasis is placed today on the transfer of collected material to central treatment areas by water, making the wet collector an effective unit for the sluicing of collected dust to settling pond, wet flotation plant, or even rock feed or storage. Where material can be collected dry and returned to the process by conveyor without upsetting production flow, the dry centrifugal or fabric-type collector finds application. While the electric precipitator type of unit offers the highest collection efficiency, its initial and operating cost is seldom justified by the particle size encountered in material handling systems. In most systems in this group, dry centrifugal and dynamic precipitating types of

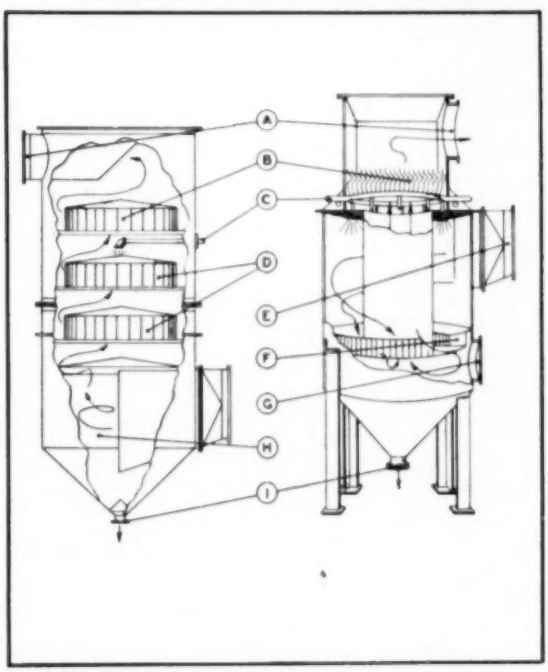

Fig. 3—Wet-type centrifugal collectors. A. Clean air outlet. B. Entrainment separator. C. Water inlet. D. Impingement plates. E. Dirty air inlet. F. Disintegrator. G. Inspection door. H. Wet cyclone for collecting heavy material. I. Water and sludge drain.

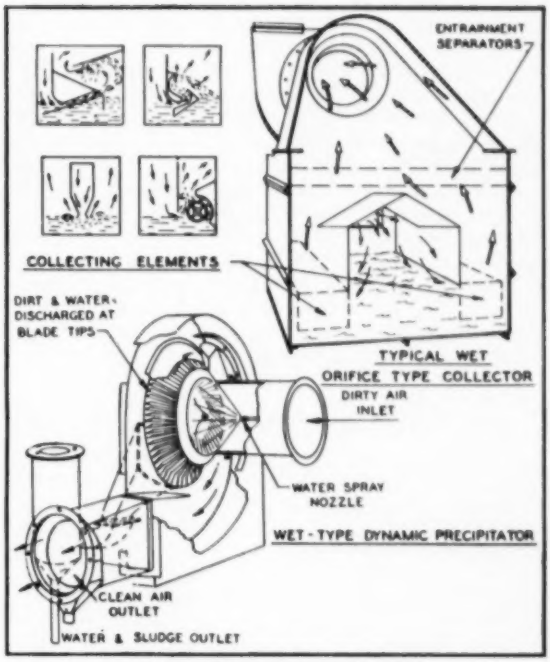

Fig. 4—Wet-type dust collectors.

units provide collection efficiencies in the order of 60 to 85 pct. The fabric-type collector and many wet-type collectors yield collection efficiencies of 98 pct and higher.

High Temperature Gas Cleaning

Dust control measures for driers, kilns, roasters, and furnaces introduce additional problems not encountered in material-handling dust control. In rotary units like the concentrate drier, kiln, or cooler, adequate air volumes must be handled within the drum to maintain proper temperatures. With restrictions imposed by the physical characteristics of the drum itself and the cascading of the material through the combustion gas stream, high pickup conditions usually exist. High temperature gases with their high moisture content introduce problems in the selection of suitable dust control equipment. While the dry centrifugal collector is the simplest approach to the collection of the escaped material, the lower efficiencies obtained usually restrict such collectors to service as a primary or scalping collector. Wet collection equipment is practical for many operations in this group. It is difficult to apply fabric collectors because of the moisture or temperatures encountered. Condensed moisture from the exhaust gas will cause plugging by filling the pores of the fabric itself, creating excessive pressure drop and reduced air volume.

With the metallic fumes released from roasters and sintering furnaces, and with the need for dry salvage of the material in the stack gases, the fabric collector or the electric precipitator is indicated and is used extensively in the lead and zinc field. Cooling of gases is necessary in either case with temperature limits on fabric arresters in the 180° to 200°F range. New media fabrics available on today's market, nylon, orlon, glass cloth, and others, may increase the potential use of this type of application. In many of these applications, the functioning of the wet-type collector is hampered by high corrosion rates with the release of sulphur compounds in many

of the roasting or furnace processes. There are, however, applications for wet-type collectors in the furnace and roaster exhaust field. Test data from copper anode electric furnace systems exhausted by local hoods and wet hydrostatic precipitators illustrate application of this type of equipment. Approximately 34 tons of copper oxide are collected each month of 8-hr operating days from the exhaust gases of two such furnaces. Exhaust volume is 21,000 cu ft at standard conditions. With 40 pct of this material less than 10 microns in size, collection efficiency of 95 pct is reported and makes possible an appreciable saving of copper oxide in addition to controlling a troublesome fume problem. Wet collectors, rubber-covered, have proved effective for roasting operations in uranium ores.

Lead Sintering

In the lead smelting field, the basic operation of the D and L sintering machine requires movement of air to sustain the process. The loss of salvageable material and atmospheric contamination require maximum dust control measures. The low efficiency of dry centrifugal and corrosion problems on wet-type collectors rule out these types. The fabric baghouse and electric precipitator are universally applied to this operation. Immediately following the sinter-machine process, crushing, quenching, and handling of sinter material take place. High dust loads varying from 3 to 10 grains are encountered because of the release of hot gases in handling of the porous clinker. Local exhaust control by hood enclosure over dust-releasing points and by wet-type collector systems has produced excellent results. Since the gases in the exhaust system are frequently below the dew point, duct accumulations often occur, regardless of conveying velocities. The sticky nature of the dust and the steam will rule out the application of dry collecting units. Test analyses indicate that collection efficiency better than 99 pct, reported as lead, can be achieved with good wet collectors.

At one plant, prior to the installation of an exhaust system collecting sintered dust from the escape gas, corrosion was taking an annual toll of equipment and plant structures. The annual expenditure for building and equipment replacement exceeded the initial cost of the dust-collecting system itself. Furthermore, the material salvaged was value received and conservation of natural resources.

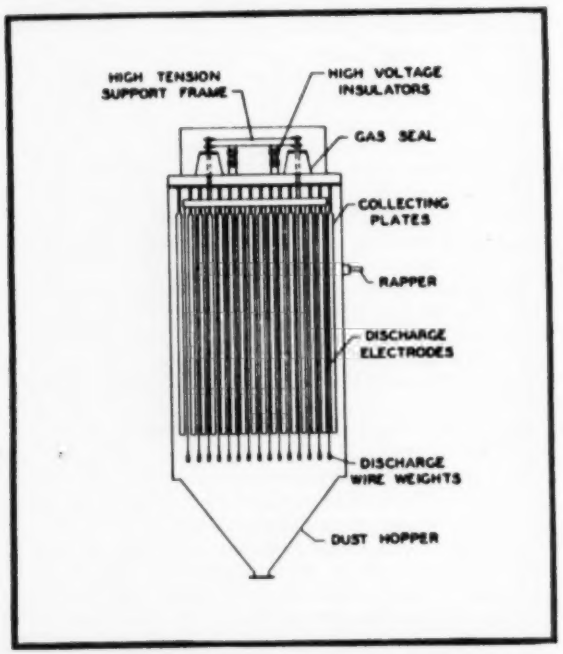

Fig. 5—High voltage electro-precipitator.

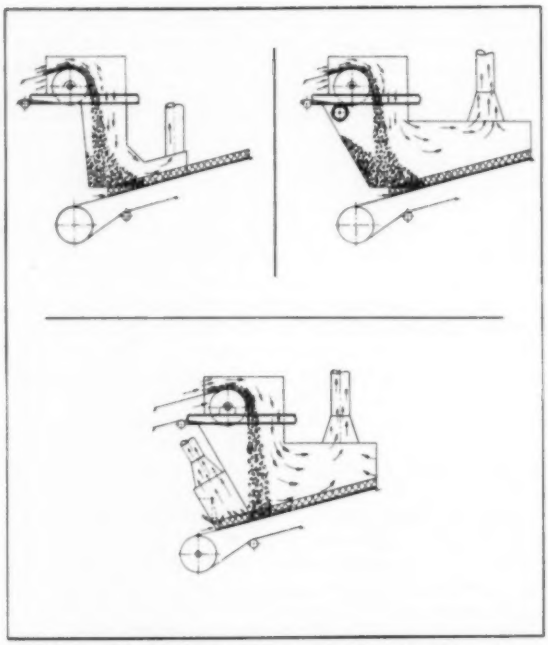

Fig. 6—Exhaust hooding for conveyor transfer points. In the poor design, upper left, and the improved design, upper right, the ore pocket breaks the fall on the belt. In the lower design the material falls directly on the belt. Two exhaust connections are required along the conveyor, none at the top.

Dust Disposal and Salvage

The means of material salvage are varied within the industry. In the milling and sampling operations where flotation processes are accessible, the use of water to sluice collected material has proved successful. Since flotation operations generally have large water volumes available, slurry piping from collectors of the wetted dust is feasible. Open sluices have an advantage where gravity flow is used, as they are easily inspected for possible accumulations. The flow is generally to thickeners, then to flotation mills. Very frequently the value content in the dust is twice that of the mine-run ore. Where flotation is not accessible, the wetted material can be returned either directly to thickeners or through them to ore supply dumps without ore volume's appreciably increasing the moisture content of the raw ore. Another approach is to remove material from the collector in a sludge state, disposing it on conveyor belts ahead of secondary crushers or storage hoppers. Again, addition of this degree of moisture is not a factor of concern because of the low ration of water to raw ore supply. Where outside space permits, air drying of the sludge can be achieved, permitting the dried material to be reintroduced into the process by mixing with other supply materials. Slurry-type filters and filter presses are also used to remove moisture from sludge prior to rehandling of collected material.

In milling fields where dry collectors are employed, the collected material is returned from the process by conveyors or transfer chute.

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aime NEWS

Los Angeles Prepares Welcome for AIME Annual Meeting

A little more than a month remains before the 175th General Meeting of the AIME convenes in Los Angeles at the Statler Hotel, February 16 to 21. Practically all major details of planning have been completed.

More than 2500 persons are expected to attend what promises to be the most outstanding program ever presented by the Institute. Technical sessions, social events, field trips, and the many informal, impromptu gatherings, usual at General Meetings, will make for a full week. Hosts to the meeting will be the Southern California section, with meeting plans under the chairmanship of Henry T. Mudd.

Minerals Beneficiation Div. will hold 10 technical sessions to be complimented by the Scotch Breakfast, divisional luncheon, and participation in the Mining Branch and all-Institute functions. MBD and EMD will join in an *Educational Training* session, Tuesday afternoon. Wednesday afternoon MBD will hold a joint session with the Industrial Minerals Div. on *Milling Methods*. MBD business meeting is scheduled for Monday, at 10:30 am.

First session of the Minerals Industries Education Div., will be held Sunday afternoon and evening and will include a buffet supper. Another session will be held Monday morning on *Problems, Enrollment*.

Early Pueblo days are relived in the oldest street in Los Angeles, noted for its gayety, quaint shops and fine Mexican food.

View across MacArthur Park shows downtown Los Angeles in the background. Social Events, field trips, technical sessions and informal gatherings in the Southern California setting will mark the 1953 Annual Meeting.

Society of Economic Geology holds its first session Monday morning on *Mineral Deposits of S.W.* Discussion will be resumed in the afternoon. Another session Thursday morning will take up *Ore-Forming Fluids*. A clean-up session will be held in the afternoon.

The annual business meeting is scheduled for the Statler, Tuesday, 4 pm, while at 5 pm the executive session of the Board of Directors will convene. The executive committee of the Industrial Minerals Div. meets Thursday at 4:30 pm.

Scheduled for Monday at 12:30 pm, the welcoming luncheon will have a national figure as the chief speaker. Outstanding talent from the entertainment world will be featured at the pre-smoker cocktail party and the dinner-smoker. Members are being asked to sponsor student participation in the dinner-smoker. Divisional dinners will take place Tuesday evening, before the informal dance. The president's reception and annual banquet is set for Wednesday evening.

The WAAIME luncheon and fashion show will be held Thursday. Tours have been arranged to the Hollywood studios for the ladies, among other activities.

To Release 1952 Transactions Volumes

AIME Transactions volumes 193, 194, and 195, which are respectively the Mining, Metals and Petroleum volumes will be released on Mar. 15, 1953. The volumes correspond to the Transactions sections of the three branch publications that were published in 1952. The price for these books is $4.90 to Members and $7.00 to nonmembers, however, if ordered and paid for with the dues, the price is only $3.50 for Members.

Industrial Minerals Div. Revised Bylaws To Be Approved At Annual Meeting

The Annual Meeting in February, 1952 was the starting point of the bylaw revision of the Ind. Min. Div., at that time a committee made up of J. V. Beall, Oliver Bowles, Ian Campbell, R. M. Foose, J. L. Gillson, H. I. Smith and R. J. Lund was appointed to examine and make recommendations to the Industrial Minerals Executive Committee for improving the Division bylaws. The committee, known as the Bylaws and Organization Committee, was also commissioned to investigate the organization of the Ind. Min. Div. and to reduce or increase the number of working committees as was necessary to improve efficiency and flexibility.

After a great deal of time-consuming effort, the Bylaws and Organization Committee has submitted the bylaws for final approval at the Annual Business meeting of the Division.

Note the omission of an abbreviation for the division name. This is to be selected at the business meeting.

Bylaws
Industrial Minerals Div.

Article I
Name and Objects

Section 1: This Division shall be known as the Industrial Minerals Division of the American Institute of Mining and Metallurgical Engineers. The official abbreviation of the Division's name shall be —.

Section 2: The objects shall be to promote the arts and sciences connected with the economic production of industrial minerals (non-metallics) and the professional standing of those employed in those industries, to hold meetings for social intercourse and the reading and discussion of professional papers, and to circulate by means of publications the information thus obtained.

Article II
Members

Section 1: Any member of the AIME in good standing may become a member of this Division by written notification to the Secretary of the Institute.

Article III
Dues and Assessments

Section 1: Dues or assessments may be fixed by the Executive Committee of the Division, subject to the approval of the Board of Directors of the AIME.

Section 2: The funds of the Division shall be disbursed as approved by the Executive Committee, by the Chairman and Secretary-Treasurer, or by officers empowered by the Executive Committee to act for them.

Article IV
Meetings

Section 1: The Division shall meet at the same time and place as the annual meeting of the AIME and at such other times and places as may be determined by the Executive Committee subject to the approval of the Board of Directors of the AIME.

Section 2: The annual business meeting shall be held during the Annual Meeting of the AIME, at which the new officers shall be installed, or elected as provided in Article VII, Section 3.

Section 3: A Divisional business meeting may be convened by order of the Executive Committee at any meeting of the Division for which notice has been sent to the members of the Division through the regular mail at least thirty (30) days in advance and any business be transacted not inconsistent with these Bylaws or with the Constitution or Bylaws of the AIME.

Section 4: For the transaction of Divisional business at any meeting, the presence of a quorum of not less than 25 members of the Division shall be necessary.

Article V
Officers and Government

Section 1: The Officers of the Division shall consist of a Chairman, at least four Vice-Chairmen (one of whom shall be designated Senior Vice-Chairman), and a Secretary-Treasurer. The Vice-Chairmen shall be chosen to represent at least four major geographical areas in the United States—East, Central, South, and West—and any additional areas that the Division may designate for additional Vice-Chairmen.

Section 2: The government of the affairs of the Division shall rest in an Executive Committee, insofar as is consistent with the Bylaws of the Division and the Constitution and Bylaws of the AIME.

Section 3: The Executive Committee shall consist of the Past Chairman, the Chairman, the Vice-Chairmen, Secretary-Treasurer, (ex-officio), and nine members, all of whom (except the Past Chairman) shall be nominated and elected as provided hereafter in Article VII.

Section 4: The Chairman and Vice-Chairmen of the Division shall serve one year each, or until their successors are elected. In case of resignation, death, or disability of the Chairman, he shall be succeeded by the Senior Vice-Chairman. The nine elected members of the Executive Committee shall serve for three years.

Section 5: With the exception of the Secretary-Treasurer, no officer or member of the Executive Committee may be immediately re-elected to the same office.

Section 6: For the transaction of business at meetings of the Executive Committee, the presence of a quorum of not less than five members shall be necessary, together with sufficient proxies to give a total of at least eight, including those present and proxies. In the event a member cannot attend, he may deliver his proxy to any member of the Division he wishes to designate, or to the Chairman or the Secretary-Treasurer to bestow as they may best decide.

Article VI
Committees

Section 1: There shall be the following standing Committees: Nominating, Membership, Program, and such technical committees as may be authorized by the Executive Committee. In addition, there shall be an Auxiliary Publications Committee, auxiliary to the Institute Technical Publications Committee, personnel of which shall be appointed by the President of the Institute as recommended by the Chairman of the Division. The term of office of members of the Auxiliary Publications Committee shall cover an annual period from October 1 to October 1. By no later than August 1 of each year, the Division Chairman shall recommend to the Secretary of the Institute the personnel of the Auxiliary Publications Committee to be appointed by the President and confirmed by the Board at its September meeting.

Section 2: The Chairman of the Division shall appoint the Chairmen of all committees other than the Auxiliary Publications Committee, the personnel for which he shall recommend to the Secretary of the Institute as provided in the preceding Section. If he so desires, he may leave the selection of committee personnel to the individual committee chairmen.

Section 3: The duties of the technical committees shall be to advance the art and science of the industry in the field of their assignment and to secure papers for presentation at meetings of the Division and of the AIME, subject to the regulations of the AIME Technical Publications Committee.

Section 4: The Executive Committee shall have the power to set up new committees, consolidate or abolish existing committees, or change the name of committees.

Article VII

Nominations and Elections of Officers and Committees

Section 1: Every year the Division shall elect a Chairman, the Vice-Chairmen, a Secretary-Treasurer, and three members of the Executive Committee.

Section 2: On or before June 1 the Nominating Committee shall report its slate of officers to the Executive Committee, which in turn will report the slate to the Secretary of the Institute. The full slate of nominees will be published in the July issue of MINING ENGINEERING. Other nominations for the offices may be made and endorsed by ten members and forwarded in writing to the Secretary of the Institute up to October 1 for publication in the November issue of MINING ENGINEERING. If such nominations are made, an election shall be held by letter ballot to be completed by December 31. If no such additional nominations are received, the candidates nominated by the Nominating Committee shall be considered elected and shall take office at the annual meeting.

Section 3: It shall be the duty of the Chairman-Elect informally to designate the Chairmen of all committees in sufficient time prior to the annual meeting to allow the Chairmen, in turn, to complete the designation of their full committee memberships before the annual meeting. At this meeting they shall be formally presented to the Executive Committee for approval. The Division Chairman, when making such appointments, shall make clear to his committee chairmen the objectives of the committee's activities during the coming year; committee chairmen, in turn, shall do the same in appointing members of their committees. Every effort shall be made by committee chairmen to hold a meeting of their committees when the new slate takes office for a new term at the time of the annual meeting.

Article VIII

Amendments

Section 1: Proposals to amend these Bylaws shall be made in writing by the Executive Committee or by petition to the Executive Committee signed by at least ten members. They shall be considered by the Executive Committee and announced to the members through the columns of MINING ENGINEERING, together with any comments made by the Executive Committee thereon. They shall be voted upon at the annual meeting of the Division or by letter ballot, as may be directed by the Executive Committee.

Annual Meeting News and Notes

Annual Meeting Field Trips Planned

Several field trips are being contemplated for Feb. 20 and 21 as adjuncts to the AIME Annual Meeting. Those expecting to attend the Los Angeles gathering have been asked to indicate their preferences.

Among the trips thus far contemplated are: Riverside Cement Co. (Crestmore mine), Kaiser Steel Co. (Fontana plant and Eagle Mountain mine), mines, oil fields and refineries, petroleum research laboratories, cement companies, steel and metal fabricating plants, automobile and aircraft plants, rock product companies, aerial trips over Los Angeles and Catalina Island, Palomar Observatory, and others.

Student Activities To Be Held At Annual Meeting

Student Associate members of the AIME can attend the 175th General Meeting without payment of the registration fee. Nonmember students will be required to pay $1.

All registered students will be given badges admitting them to technical sessions. Students will also be presented with a packet of technical papers without charge.

Open to students without charge will be the dinner and panel discussion *Modern Mineral Engineering Curricula*, sponsored by Mineral Industry Education Div. A charge of $5.00 will be made to students desiring to attend the Welcoming Luncheon. Admission to the entertainment portion of the Stag Dinner will be without charge to students. AIME members are being asked to act as sponsors for students desiring to attend the dinner as well.

A special student session, *Opportunities in Mineral Engineering*, has been arranged, with six prominent AIME members to address the group.

C. M. Squarcy To Receive Johnson Award

Kurt Neustaetter, Chairman of the J. E. Johnson, Jr., Award Committee, announced to the Board that the committee had selected Charles M. Squarcy, assistant superintendent blast furnaces, Inland Steel Co., East Chicago, Ind., to receive the J. E. Johnson, Jr., Award for 1953. The citation offered to accompany the award reads as follows: "for his ability as a blast-furnace operator, for his contributions to blast-furnace literature, and for his work in building this professional organization." Mr. Squarcy will be invited to be a guest of honor of the Institute at the Annual Banquet.

John H. Chesters Awarded Hunt Medal

K. C. McCutcheon, Chairman of the Robert W. Hunt Medal and Prize Committee, announced that the committee had selected J. H. Chesters, assistant director of research, United Steel Companies, Ltd., of Sheffield, England, to receive the award in 1953. The award is being presented to Mr. Chesters for his paper entitled, *Flow Patterns in Open-Hearth Furnaces*, published in the 1951 Open Hearth Proceedings. A silver medal will be awarded to Mr. Chesters at the Annual Banquet to which he will be invited as a guest of honor of the Institute.

Special Tour Planned

AIME members from the east are invited to travel to Los Angeles via the AIME special train from Chicago. This train will leave Chicago at 11:55 am (Central Time) on Friday, Feb. 13, 1953 and stop at Salt Lake City on Saturday. There will be a 3 hr tour of the Utah open cut copper mines in Bingham Canyon.

The train will leave Salt Lake City at 9:00 pm (Mountain Time) and arrive at Las Vegas on Sunday. There will be a bus tour to Boulder City and Hoover Dam, and a sightseeing tour at the casinos of Las Vegas. The train will be boarded at 9:00 pm (Pacific Time) Sunday, and the last stop will be Los Angeles, 7:30 am Monday. Interested persons should make reservations now by writing J. J. Cummins, Traveling Passenger agent, Union Pacific R.R., 1 S. LaSalle St., Chicago 3.

Mathewson Gold Medal Winners Named

The following selections as winners of the Mathewson Gold Medal for 1953 were announced to the Board, as presented by M. B. Bever, Chairman of the Mathewson Gold Medal Committee: Paul A. Beck, Hsun Hu, and P. R. Sperry. The award-winning series of closely related papers, published in JOURNAL OF METALS Transactions, are: *Annealing Textures in Rolled Face-Centered Cubic Metals*, by Paul A. Beck and Hsun Hu; *Rolling Textures in Face-Centered Cubic Metals*, by Hsun Hu, Philip R. Sperry, and Paul A. Beck; and *Recrystallization Texture and Coarsening Texture in High Purity Aluminum*, by Paul A. Beck and Hsun Hu.

Each will receive the Mathewson Gold Medal during the Annual Meeting in Los Angeles in February and will be guests of honor at the Annual Banquet.

New Local Sections Formed in Southwest

A new Local Section of the AIME, to be known as the West Central Texas Section, has been formed. Headquarters will be in Abilene. Its area embraces the following counties, which have been released by the Permian Basin and North Texas Sections: Scurry, Mitchell, Stonewall, Fisher, Nolan, Coke, Haskell, Jones, Taylor, Runnels, Shackelford, Callahan, Coleman, McCullough, Stephens, Eastland, Comanche, Brown, Mills, San Saba, Hamilton, Lampasas, and Coryell.

An application and bylaws for the formation of the Lou-Ark Local Section were approved at the recent meeting of the Board of Directors. The Section will include all that area in the states of Arkansas and Louisiana previously included in the East Texas Section which has signified its willingness to release this area. The area is bounded on the west by the western boundaries of Louisiana and Arkansas, on the north by an east-west line passing through Hot Springs Station across Arkansas from Oklahoma to the Mississippi River, on the east by the Mississippi River, on the south by a straight line beginning at the Sabine River, passing through Torras and Fullerton, La., and terminating at the Mississippi River. This Section will be among those administered by the Petroleum Branch.

Approval of the transformation of the South Plains Subsection of the Permian Basin Section to the South Plains Local Section has been given by the Board of Directors. The Permian Basin Section approved the release of this territory. The new Section will include the following counties of Texas: Bailey, Yoakum, Lubbock, Crosby, Dawson, Dickens, Floyd, Cochran, Cottle, Hale, Hockley, Kent, King, Gaines, Garza, Lynn, Motley, and Terry. This Section will also be administered by the Petroleum Branch.

No Change In Institute Name Planned

All discussions regarding any suggested change in the name of the Institute, have indicated that there is no particular desire for any change. No enthusiasm has arisen for the name "American Institute of Mineral Engineers." "American Institute of Mining, Metallurgical and Petroleum Engineers" is too unwieldy. "American Institute of Miscellaneous Enginners" is only good for a laugh. One suggestion is perhaps worthy of consideration: On all letterheads, carry the names of the ten Divisions of the Institute.

Loeb, Behre, Address Boston Section Meeting

Carl M. Loeb, Jr., vice president of Climax Molybdenum Co. spoke to the members of the Boston Section at the Faculty Club of MIT, Cambridge, Mass., on *Molybdenum Today and Tomorrow.*

At another gathering of the group, held at the Smith House, Cambridge, Charles H. Behre, Jr., professor of Economic Geology, Columbia University, addressed the group on *The Geologic Setting of the Mexican Mineral Industry.*

Minnesota Beneficiation Sub-Section

The Minnesota Section's Minerals Beneficiation Sub-section heard, at its last meeting, Jack Bond of the Nordberg Manufacturing Co., deliver a talk on crushing, with particular emphasis on taconite concentration.

The Sub-section has appointed a committee to maintain a liaison with the Mining Branch for the exploration of possibilities of an equipment show on mineral dressing. If the project is successful it is hoped to have similar shows yearly, with mining alternating with concentration equipment.

Arizona Geology Branch Visits Bagdad Properties

Charles A. Anderson of the U. S. Geological Survey presented a concise summary of the geology of the Bagdad area, including the Bagdad mine, to the Mining Geology Branch of the Arizona Section.

A talk on the Old Dick zinc mine was presented by James H. Cazier, of the Bagdad Copper Corp., followed by E. A. Scholz, Hillside Mining and Milling Co., who discussed the highlights of the Tungstona and Black Pearl tungsten mines.

After a briefing session, the party visited a breccia pipe of the Bagdad property, followed by a visit to the Old Dick mine.

Spokane Joint Meeting Hears Fankuchen Speak

The Columbia Section, in joint sponsorship with the American Metals Society, and the Inland Empire Chemists held a dinner-meeting at the Spokane Hotel, Spokane, Wash., with I. Fankuchen, head of the Div. of Applied Physics at Brooklyn Polytechnic Institute, as the main speaker.

His subject, *New Developments and Applications of X-Ray Defractions*, was of especial interest to the geologists, mining engineers, metallurgists, analysts, and chemists who

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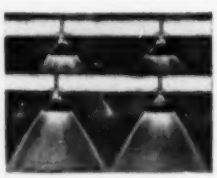

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attended. Scientific Supplies Co. sponsored a cocktail hour prior to the dinner.

Columbia Section, with AIME members from Canada, Washington, and Idaho visited Metaline Falls, recently, as the guests of the Pend Oreille Mining Co. and the American Zinc Co. Several tours of underground and surface installations were made. Leading equipment companies sponsored a social hour, followed by a dinner.

The Columbia Section joined the Founder Societies in the Inland Empire in commemorating a Centennial of Engineering, during the week of September 30. The extensive five-day program included grade and high school students interested in the engineering profession.

Ajo Elects Chairman

The Ajo Subsection, at Ajo, Arizona, elected Orazio Finzi chairman, Ted Page, vice chairman, and John Newitt, secretary-treasurer.

Utah Section Hears Of Lark Mine Fire

Oscar A. Glaeser, assistant manager of U. S. Smelting, Refining and Mining Co., discussed the Lark mine fire at the meeting of the Utah Section, held at Salt Lake City.

W. G. Rouillard, chairman of the group presided over the meeting which attracted 119 members.

To Invest AIME Funds in Common Stock

At the recent Board meeting, consideration was given investing an increased portion of AIME funds in common stocks rather than bonds or preferred stocks. Permission was voted to allow the Investment Committee to invest up to 50 pct of Institute funds in common stocks except where special conditions or limitations exist, as in certain specific Funds. The instruction was permissive and not directive.

Petroleum Branch To Issue Cumulative Index

A cumulative index of petroleum papers published by the AIME to date is to be issued by the Petroleum Branch. Its cost will be underwritten by the Branch's Special Projects Fund and it is expected that sales to members will cover at least half the cost. Papers in the Transactions volumes will be indexed, and also other important material in *Petroleum Technology* and the JOURNAL OF PETROLEUM TECHNOLOGY. The last all-Institute cumulative index covered material published through 1936.

Albuquerque Hosts S.W. Mineral Conference

Albuquerque was the focal point of *Mining Week In New Mexico* as more than 1000 persons flocked to the city for the Southwest Mineral Conference.

Talks by government, industry and education leaders highlighted the conference. A special feature of the first session was a color movie called, *Mining in the Land of Enchantment*, tracing the industry through the stages of prospecting, exploration, development, mining and smelting.

Technical sessions, a banquet and other social and professional events filled the three-day conference.

N. Mex. Geological Society Field Trip

The New Mexico Geological Society held its third annual field conference on the subject of the Rio Grande country, with more than 230 geologists in the party.

The tour started at Santa Fe, leading past the old coal mining camp of Madrid to the south, and past the placers at Golden and the copper mine at San Pedro. Along the back slope of the Sandia Mountains the geologists saw a variety of features of stratigraphic and structural interest. The route from Albuquerque south along the east side of the Manzano Mountains was studied on the second day. The last day of the conference the old Carthage coal mining district was visited. After luncheon, the geologists proceeded to Caballo Reservoir and then to Elephant Butte Dam.

John E. Allen of the New Mexico Bureau of Mines was general chairman of the conference, and Brewster Baldwin of the Bureau handled the trip and caravan arrangements.

New Addressograph Installed By AIME

Modernization of operations at AIME headquarters called for new addressograph equipment.

In changing the tabbing on 20 thousand stencils, it is possible that some mistakes were made so if you did not receive your journal last month, or you received the wrong journal, or too many copies, please drop us a line.

Mining Trans. Vol. 190

Demand has exceeded expectations for the Mining Transactions volume for 1951, No. 190, and it is now out of print. Copies have been sent to many members who have only recently paid their 1951 dues.

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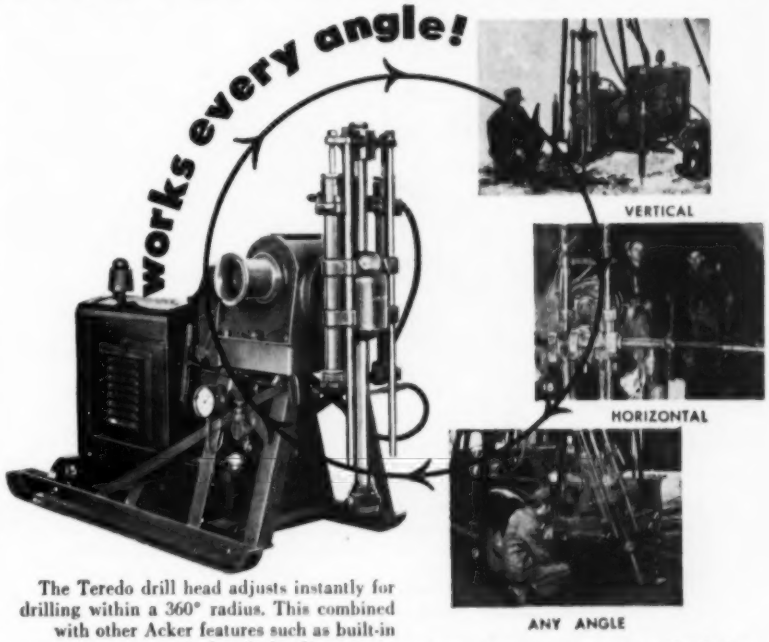

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Personals

Floyd E. Albertson is now in Coeur d'Alene, Idaho. He had been working for the Mauricio Hochschild interests as mill superintendent of Cia Minera de Oruro, Seccion Colquiri.

James A. Barr, Jr. has resigned his position with Armour Chemical Div. and has taken an assignment on the Atomic Energy Commission at Washington, D. C.

Luther R. Branting, works manager of Alcoa Mining Co.'s bauxite operations, has retired after more than 32 years active service.

John N. Butler is project engineer in charge of uranium ore beneficiation research being done on contract between AEC and Mackay School of Mines, University of Nevada.

A. B. Chafetz, plant engineer, has been advanced to assistant superintendent, maintenance and engineering dept., International Minerals & Chemical Corp., Carlsbad, N. Mex.

Parker S. Dunn was appointed vice-president of production of American Potash & Chemical Corp. He will be in charge of production and engineering at the company's plant at Trona, Calif. Mr. Dunn succeeds **Russell W. Mumford,** vice-president, who has been appointed consulting engineer at Los Angeles.

ARTHUR C. BIGLEY

EDWARD I. RENOUARD

Arthur C. Bigley of Anaconda Copper Mining Co., who has been manager of mines since January 1951, becomes general manager of Western mining operations. **Edward I. Renouard** who has been general superintendent of mines, becomes manager of mines and **A. R. Sims,** assistant general superintendent of mines, has been elevated to Mr. Renouard's former position. **Edward Bonner, Jr.** has become general superintendent of mines. **Joseph Canavan** is now foreman of the Belmont mine.

Ernest H. Dickenson, manager-director of Ingersoll-Rand Co., Ltd., has returned to the U. S. and will be located with parent company, Ingersoll-Rand at 11 Broadway, New York City.

A. J. Gould, who until recently was general foreman of the Inspiration Consolidated Copper Co. in Arizona, is now in Nevada as plant superintendent at the Yerrington copper mine of the Anaconda Copper Mining Co.

E. H. Greenwald has been appointed general manager of the Boone County Coal Corp. at Sharples, W. Va. **T. W. Cline** has been named superintendent.

W. Church Holmes, formerly with Sunshine Mining Co., has rejoined that organization and will be in charge of new projects with headquarters at Spokane, Wash.

Hugh C. Ingle, Jr. is now associated with the Teekay Mines, Inc. as a mining engineer in their operations near Tracy, Calif. He will assist in reopening underground operations at their manganese property where open-pit methods are now employed and in operations of the 100 ton mill.

L. H. Lange left on the S. S. Endeavor for South Africa for a six to eight months visit. He will visit the Tsumeb mine in South West Africa for Newmont Mining Co., also, O'okeip Copper Co. in South Africa. On his way home he will visit Southern and Northern Rhodesia and tin mines in Nigeria and the lead-zinc operation of Mines De Gelidja in Morocco.

George M. Potter has been transferred from the Salt Lake Station of the Bureau of Mines to the Foreign Minerals Region, Washington, D. C. as projects engineer.

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JOHN G. HALL

John G. Hall has taken over duties as assistant plant manager of National Lead Co.'s MacIntyre development in Tahawus, N. Y. He has worked for United States Smelting, Refining & Mining Co. as a geologist and research engineer, and for the Chief Consolidated Mining Co., where he became general superintendent.

Clifford F. Hood, executive vice president in charge of operations of United States Steel Corp. was elected president of the corporation and a member of the board of directors. Mr. Fairless will continue as chairman of the board and chief executive officer of the company. **Robert C. Tyson,** who has been controller since 1950 and a vice president since 1951, was named vice chairman of the finance committee and a member of the board of directors. **Harvey B. Jordan** was elected executive vice president of operations. Mr. Jordan has been president of the American Steel & Wire Div. since 1950. **Walter F. Munford** will fill the post created by the advancement of Mr. Jordan. **Howard E. Isham** was elected vice president and treasurer of U. S. Steel. He will succeed **Max D. Howell,** who retired.

John C. Lokken returned in December from seven weeks in Europe and the Middle East where he was visiting mines and flotation mills on behalf of the Dow Chemical Co.

Richard Matthaei has left Compania Minera Agna Fria, S. A., El Paraiso, Honduras, and is now with Tin Processing Corp., Texas City, Texas as senior engineer in the Experimental Div.

Robert W. McElroy was promoted to the newly created position of director of safety and security for Minnesota Mining & Manufacturing Co.

Charles A. Mitke has been visiting mines in Uganda, South Africa, and South West Africa on behalf of American interests.

F. R. MILLIKEN

Frank R. Milliken has been appointed a vice president of Kennecott Copper Corp., and will be in charge of the firm's mining operations in the U. S. and Chile. He served as plant manager of National Lead Co.'s MacIntyre development and later as assistant manager of the titanium div. and member of its mining committee, prior to assuming his present position.

GEORGE M. HUMPHREY

George M. Humphrey, president and chairman of the board of the M. A. Hanna Co., has been appointed to President-elect Eisenhower's cabinet as Secretary of the Treasury. Among his accomplishments have been the organization of the National Steel Corp. in 1929 and the Pittsburgh Consolidation Coal Co. in 1945. Mr. Humphrey is also credited with the organization in 1950 of Iron Ore Co. of Canada to develop Labrador-Quebec iron ore deposits.

Walter E. Seibert, Jr. has resigned as resident geologist at Reynolds Mining Corp. bauxite operations in Alexander, Ark. He is now assistant to the president of St. Lawrence Corp. of Newfoundland.

LUTE J. PARKINSON

Lute J. Parkinson has been named head of the mining dept. at the Colorado School of Mines. Mr. Parkinson succeeds Clifton W. Livingston who resigned this past summer to organize his own mining company. Graduated from the Colorado School of Mines in 1923, Mr. Parkinson was formerly a mining consultant to the Anglo-Chilean Nitrate Corp. and to Lautaro Nitrate Co., Ltd. of Antofagasta, Chile. He has had extensive experience in the mining industry in Europe, Africa, and North and South America. In 1950 Mr. Parkinson was awarded the School of Mines' highest honor with the presentation of a distinguished achievement award.

Melvin Viant has been appointed assistant superintendent of construction by the Cleveland-Cliffs Iron Co. at its Mesabi iron range operations.

Thomas L. Wells is attached to the U. S. Atomic Energy Commission as staff mining engineer, with headquarters in Washington, D. C.

T. H. Wickenden, vice president in charge of development and research of the International Nickel Co., Inc., has been elected a member of the Welding Research Council of the Engineering Foundation.

Robert C. Wilson, formerly assistant general superintendent for the El Paso Smelting Works, El Paso, has been appointed smelter superintendent for the White Pine Copper Co. in Michigan.

Louis A. Wright has changed his address from 1915 California St., San Francisco, to 243 Oxford Avenue, Palo Alto, Calif.

J. Harlan Johnson, professor of geology at the Colorado School of Mines, is now in the South Pacific doing research work on reef islands under the auspices of the U. S. Army. He is studying coral reefs, limestones and reef growths due to lime-secreting sea weeds.

Obituaries

John A. Church (Member 1907) consulting engineer and a widely known authority on minerals died recently. Mr. Church was educated at Trinity School, New York, and was graduated from the Columbia University School of Mines. He was called to Washington in 1940 to serve on the National Defense Council. Later he became head of the copper and zinc branch of the War Production Board. Commissioned a major in the Army in 1942, he acted as liaison officer with the WPB. He was sent overseas in 1945 to investigate German mineral resources. Mr. Church's early career was spent as an engineer in Mexico and Montana. Later, he became associated with the Nichols Copper Co. of New York. In 1941, he collaborated in the editing of the third edition of the Mining Engineers Handbook. He was a member of the Cosmos Club of Washington, the Mining and Metallurgical Society of America, and the Century Assn. of New York.

Thomas Walker Page (Member 1943) died September 6, 1952. He was born in Virginia and educated at University of Virginia and Montana School of Mines. Mr. Page was general superintendent for Hidden Lake Venture, Inc. and general manager for North Whitney Mines, Ltd. One of his earlier positions was as a geologist and mining engineer for International Mining Corp. Mining geology was a major technical interest to Mr. Page. From 1941 to 1943 he was assistant to C. K. Leith, R. C. Allen and F. E. Vuger with Office of Production Management and War Production Board. His latest position was with American Rolling Mill Co., at Middletown, Ohio in Mining Engineering Operations Dept. Mr. Page held a B.S. degree in geologic engineering.

Appreciation of
L. E. Hanley
by Robert E. Sorenson

L. E. (Lew) Hanley, chairman of the board of Hecla Mining Company, Wallace, Idaho, age 72, passed away on November 16th. Mr. Hanley gave his entire career to the affairs of Hecla, having joined the Hecla staff in 1902 as assayer and bookkeeper. He became timekeeper in 1907, office manager and secretary three years later and general mine superintendent in 1923. In 1940 after the death of James F. McCarthy, former president and manager, Mr. Hanley assumed those duties and continued in that position until ill health caused his retirement in May of 1951. From that time he acted as chairman of the board and consultant of Hecla.

Mr. Hanley was an excellent administrator, a loyal, friendly associate, a personal true friend of most men employed in Hecla and associated properties and his success in contacts with labor is known throughout the mining industry. The University of Idaho conferred on him the degree of Doctor of Laws in June of 1952 in tribute for the great help he has given to the school, his generous aid to prospective students, his contributions to the mining industry and his humanitarian accomplishments in the State of Idaho.

We mourn the passing of our loyal friend and associate and his kindly, friendly mien will forever be impressed upon our memory.

Appreciation of
William Joseph Loring
By H. B. Chessher

William Joseph Loring, internationally known mining engineer, suffered a fatal heart attack at Tonopah, Nev. on October 8 and was buried in Tonopah on October 13. Funeral services were conducted by Tonopah Lodge No. 28, F. & A. M., as Mr. Loring had been a member of the Masonic Order for over a half a century, having joined the Bear Mountain Lodge of Masons in Angels Camp, Calaveras County, Calif., 52 years ago. He was a member also of other

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American Institute of Mining and Metallurgical Engineers
Box BB, 29 W. 39 Street New York 18, N. Y.

Masonic bodies, including Islam Temple of the Mystic Shrine in San Francisco, Calif.

William J. (Bill) Loring was born at Half Moon Bay, San Francisco, Calif., in 1869. Early in life he moved to Plymouth, Calif., and worked in the Plymouth Consolidated Gold Mines. At the age of 17 he went to the Utica Gold Mine at Angels Camp as a mill helper, later being promoted to mill superintendent and assistant manager.

In 1901 he became superintendent of the Melones Mine at Melones, Calif. After resigning that position he became a member of the staff of Bewick Moreing & Company of London, England. In that capacity he went to West Australia, under the direction of Herbert Hoover, and later was in charge of Bewick-Moreing mining interests in various sections of the world. During the latter part of his association with that firm he held an interest in their various mining activities. He returned to California in 1915 and reopened the Plymouth Consolidated Mine, which under his direction was a large gold producer. From 1916 to 1924 he was president of the Carson Hill Gold Mine—also a large producer.

In 1917 his activities were directed toward the initial development of the Pacific Tungsten property near Mill City, Nev.—now known as the Nevada-Massachusetts Co. and presently controlled by the Segerstrom interests. Later he organized the Arizona Comstock Mining Co., which operated in Virginia City for several years—after which he devoted his attention to an attempted reopening of the Belmont Mine in Tonopah and other properties in the Tonopah area.

The town of Loring in Northern Ontario was named for William J. Loring.

He was the first president of the Mother Lode Highway Assn. and president of the American Mining Congress in 1921 and 1922. He had been a member of the American Institute of Mining and Metallurgical Engineers for over 50 years. He is survived by his widow, Vera Loring, one son, Edward Loring, and two stepsons, Samuel and William Murray.

NECROLOGY

Date Elected	Name	Date of Death
1949	George M. Brown	Unknown
1907	John A. Church	Nov. 10, 1952
1919	George M. Enos	Oct. 27, 1952
1947	Robert Gale, Jr.	Sept. 6, 1952
1921	S. B. Goldberg	Apr. 11, 1952
1943	Jerome B. Grigg	Oct. 4, 1952
1943	Julius A. Heeren	Unknown
1944	Harold E. Hostetter	Nov. 11, 1952
1917	L. G. Johnson	Nov. 16, 1952
1936	McHenry Mosier	Oct. 19, 1952
1923	A. D. Riley	Oct. 25, 1952
1937	Otto D. Rohlfs	Sept. 25, 1952
1939	T. K. Stinson	Oct. 14, 1952
1948	Howard L. Sweet	September 1952
1952	V. L. Vasilievich	Nov. 11, 1952
1914	Joel H. Watkins	Oct. 27, 1952
1939	Job H. Winwood	Nov. 4, 1952

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Oct. 31, 1952 was 18,333; in addition 1,697 Student Associates were enrolled.

ADMISSIONS COMMITTEE

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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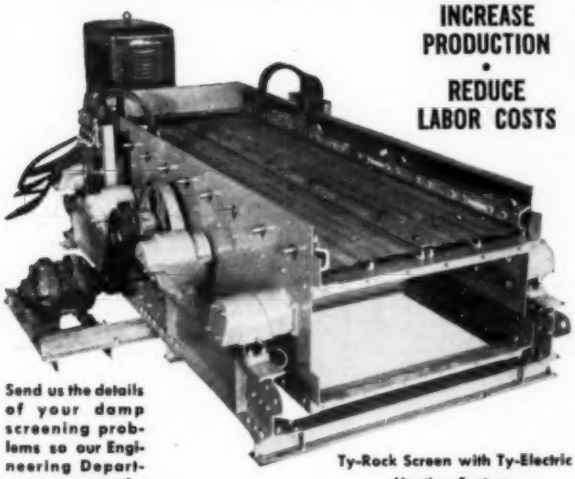

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Coming Events

Jan 6, Society for Applied Spectroscopy, Socony-Vacuum Training Center, New York City.

Jan. 14, AIME, Connecticut Section, Hammond Metallurgical Laboratory, Yale University, New Haven, Conn.

Jan. 14-16, 19th Annual Meeting of Society of Photogrammetry, Shoreham Hotel, Washington, D. C.

Jan. 21-23, Ninth Annual Technical Conference of Society of Plastics Engineers, Inc., Hotel Statler, Boston.

Jan. 26-30, American Society of Heating and Ventilating Engineers, international heating and ventilation exposition, International Amphitheatre, Chicago.

Feb. 4, AIME, Chicago Section, Chicago Bar Assn., Chicago.

Feb. 16-19, AIME, annual meeting, Statler Hotel, Los Angeles.

Mar. 8-11, American Institute of Chemical Engineers, Buena Vista Hotel, Biloxi, Miss.

Mar. 11, AIME, Connecticut Section, Brass Mill Clinic, Waterbury, Conn.

Mar. 16-20, National Assn. of Corrosion Engineers, annual conference and exhibition, Hotel Sherman, Chicago.

Mar. 23-27, ASM, Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles.

Apr. 12-May 23, Empire Mining and Metallurgical Congress, Australia-New Zealand.

Apr. 20-22, AIME, National Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Hotel Statler, Buffalo.

Apr. 25-May 10, Fifth Liege International Fair, Liege, Belgium.

May 11-14, American Mining Congress Coal Convention & Exposition, Public Auditorium, Cleveland.

May 14-16, Pacific-Northwest Metals and Minerals Conference of 1953, joint meeting of Metals Branch and Industrial Minerals Div., Ben Franklin Hotel, Seattle.

May 18-22, Fifth National Materials Handling Exposition, Convention Hall, Philadelphia.

June 3-7, Chemical Institute of Canada, Windsor, Ont.

Sept. 15-20, Joint Meeting Industrial Minerals Division, AIME, Keltic Lodge, Ingonish, Nova Scotia.

Sept. 21-23, American Mining Congress Mineral Mining Convention, Olympic Hotel, Seattle.

Oct. 19-21, Institute of Metals Division, Fall Meeting, Hotel Allerton, Cleveland.

Oct. 28-31, AIME, El Paso Meeting, in cooperation with International Mining Days, Paso Del Norte, El Paso.

Oct. 29-30, AIME, ASME Fuels Conference, Conrad Hilton Hotel, Chicago.

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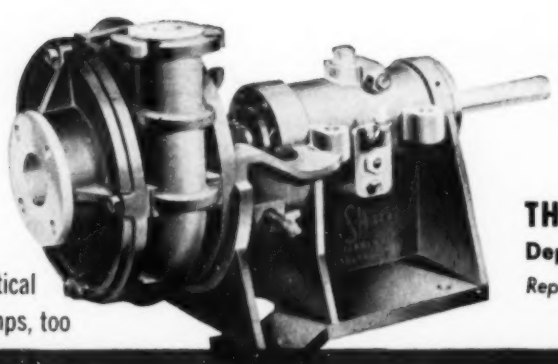

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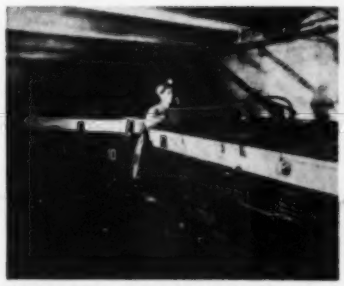
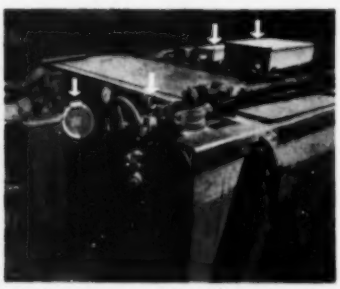


Motorman reports his position at cross-over.

Motorman, ready to go into mine, asks for right of way.

Trip unloader advises conditions at his station.



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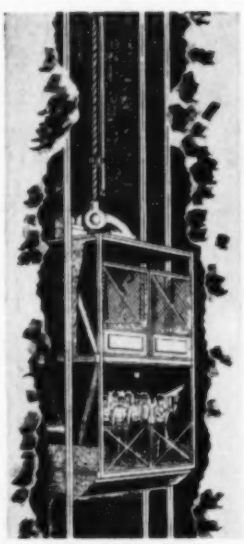

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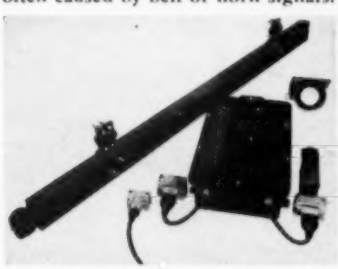

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